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Research article

Cultivation of bacterial pathogens and antimicrobial resistance in canine periapical tooth abscesses

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Abstract

This research aimed to assess the occurrence of bacterial pathogens and their antimicrobial resistance in dogs presenting with canine periapical tooth abscesses. Sample swabs were performed on 45 dogs who had undergone dental surgery between January 2019 and August 2020 at the Veterinary Teaching Hospital, Chiang Mai University. Samples were analyzed within 24 hours at the Veterinary Diagnostic Laboratory, Chiang Mai University to identify any bacterial species and to investigate their potential antimicrobial susceptibility according to CLSI guidelines. A high proportion of gram-negative and facultative species were identified. Out of the 17 species obtained, *Pseudomonas aeruginosa* (34.6 %) was determined to be the predominant species followed by *Escherichia coli* (15.4%) and *Klebsiella pneumoniae* (11.5%), respectively. *P. aeruginosa* was highly resistant (100.0%) to ampicillin and clindamycin, while *E. coli* and *K. pneumoniae* were found to be highly resistant (100.0%) to clindamycin in terms of antimicrobial susceptibility. However, *E. coli* was more resistant to enrofloxacin, gentamicin, and norfloxacin than *K. pneumoniae*. When focusing on the resistance rates of all species, clindamycin exhibited the highest degree of resistance, followed by ampicillin and amoxicillin, respectively. Amoxicillin-clavulanate is an empirical antibiotic in our area that has exhibited a resistance rate of 48.7%. The outcomes of our study have suggested that fluoroquinolone and aminoglycoside could be used to treat canine periapical tooth abscesses. However, the renal effect of these drugs must be considered. Importantly, antibiotic selection must depend upon the results of bacterial culture and antimicrobial susceptibility tests in order to reduce any potential antimicrobial resistance issues.

Keywords: Antibiotic resistance, Bacterial pathogen, Canine, Periapical tooth abscess

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INTRODUCTION

Dentoalveolar abscesses in humans have not been advertently discussed since the late 1900s (Shweta and Prakash, 2013). However, more studies on this disorder are currently being conducted. Periapical tooth abscesses or dental abscesses are a common disorder present in small animals, exotic pets, and humans. Acute inflammation occurs when bacteria enters the periapical tissue via the apical foramen and stimulates the formation of pus (Nair, 2004). This has been found to result in severe infections that can lead to the destruction of the alveolar bone (Külekçi et al., 1996) and cause a range of painful conditions. Although the severity of these infections is often underestimated, they have led to morbidity and mortality in guinea pigs and rabbits (Robertson and Smith, 2009). A case reported in 1974 by Neuman revealed that a clinical sign of a carnassial tooth abscess was represented by a chronic ocular discharge in the Lhasa Apso breed. The cause of the canine dental abscess may have originated from severe periodontitis, a tooth fracture, or a retained root following a tooth extraction (Kealy and McAllister, 2000); however, proper diagnosis should be confirmed by dental radiography (Neuman, 1974). The teeth that have typically been associated with carnassial abscesses in dogs were the upper fourth premolar and the first and second premolar (Adepu et al., 2018). A previous study has revealed a fairly high rate of incidence for this type of abscess at 22.7% in rabbits and 6.7% in guinea pigs (Jekl et al., 2008; Minarikova et al., 2016).

In general, the oral cavity has over 100 billion bacteria per gram of oral cavity (Silness and Loe, 1964). The common bacteriological pathogens of dental abscesses are comprised of polymicrobial species that can contribute to a complex array of diseases; therefore, it may be necessary to use a combination of methods for effective treatment, such as extraction of the affected tooth, the removal of the infected bone, wound debridement, centralized pain relief, and the administration of antibiotics (Minarikova et al., 2016). An untreated dentoalveolar abscess can spread to the anatomic structure and cause serious complications (Shweta and Prakash, 2013). Veterinary dentistry recommends the administration of clindamycin, amoxicillin, amoxicillin-clavulanate, and metronidazole to treat periodontitis (Albuquerque et al., 2012; Senhorinho et al., 2012; Nelson et al., 2013). Notwithstanding, drug selection is crucial and should be based on bacterial culture and drug sensitivity for optimum treatment effectiveness.

Nowadays, the problem of antimicrobial resistance is progressing globally and has contributed to rising mortality and morbidity rates, economic losses, and prolonged periods hospitalization worldwide (Regmi et al., 2019). One of the factors associated with increased drug resistance is the widespread use of antibiotics in current clinical practice, including the selection of antimicrobial drugs based on either discrimination or manifestation. Consequently, multidrug resistance has become a growing problem. Furthermore, while antibiotics are increasingly prescribed to treat severe periodontitis or dental abscesses in dogs, findings on the study of bacterial strains in canine dental abscesses have rarely been published, including with regard to information on antibiograms. Hence, this research aimed to determine the bacterial species of the periapical abscess and its antimicrobial susceptibility. The data obtained from this research study can be used to recommend effective and appropriate empirical antibiotics for veterinary clinical practicetioners.

MATERIALS and METHODS

Study subjects

This study was performed on 45 dogs who underwent dental extraction surgery at the Small Animal Teaching Hospital (SATH), Chiang Mai University (CMU) between March 2019 and August 2020. The inclusion criteria for all animals entered in this study stipulated the inclusion of healthy dogs with moderate to severe periodontitis and dental abscesses. The diagnosis of a dental abscess can be based on the clinical signs of severe periodontal disease or abscesses and a thorough oral examination. Ultimately, the diagnosis must be confirmed by dental radiography. Moreover, the dogs included in this study had no history of taking antibiotics and had received no oral disease treatments for at least three months prior to being enrolled in this study. If dogs had been diagnosed with any systemic diseases or were given a score of more than 2 on the American Society of Anesthesiologists (ASA) physical status scale, they were excluded from this study.

Data collection

The health status of the dogs who participated in this study was confirmed by physical examination, complete blood count, blood biochemistry profiles, and thoracic radiography before surgery. The relevant data of each subject were also recorded including specific details of age, sex, oral problems, and any applied forms of dental home care. This research protocol was approved of by the Animal Care and Use Committee of Faculty of Veterinary Medicine (FVM-ACUC), Chiang Mai University (Ref. no. R1/2561).

Sample collection

For bacterial examination, all samples were collected using an aseptic technique during the surgical procedure. For the appropriate sample collection for each dog, more than one sample swab was collected depending on the number of dental abscess sites in the subject's oral cavity. Swabbed samples (e.g., pus, affected bone or tissue, and abscess capsules) were placed into Stuart's transport medium. All samples were stored at 4˚C and the appropriate laboratory processes were performed within 24 hours at the Veterinary Diagnostic Center, Faculty of Veterinary Medicine, Chiang Mai University.

Bacterial identification

The standard bacterial identification procedure was performed according to the Clinical and Laboratory Standards Institute (CLSI, 2014). The suspected bacterial colony was cultured onto tryptic soy agar comprised of 5% sheep's blood agar and MacConkey agar (Difco™ Laboratories, US) and incubated at 37˚C for 24-48 hours. Bacterial colonies were identified based on gross morphology, hemolytic pattern, gram staining, and biochemical characterization.

Antimicrobial susceptibility testing

For all highly significant isolates, the Kirby-Bauer disk diffusion method was performed for antimicrobial susceptibility testing according to the CLSI guidelines. Pure colonies obtained from the highly significant isolate were inoculated into trypticase soy broth (TSB: tryptic soy broth himedia™, India) and incubated at 37˚C for 8-12 hours. After incubation, the standard turbidity of each bacterial suspension was adjusted to a turbidity equivalent of 0.5 McFarland. The adjusted TSB was inoculated onto Mueller-Hinton agar (MHA: Difco™ Laboratories, US) using a sterilized cotton swab. Antibiotic disks (Oxoid™, UK), which contained amoxicillin (AML, 25 μg), ampicillin (AMP, 10 μg), amoxicillin/clavulanic acid (AMC, 30 μg), ceftiofur (EFT, 30 μg), ceftriaxone (CRO, 30 μg), cephalexin (CL, 30 μg), cephazolin (KZ, 30 μg), clindamycin (DA, 2 μg), doxycycline (DO, 30 μg), enrofloxacin (ENR, 5 μg), gentamicin (CN, 10 μg), imipenem (IPM, 10 μg), norfloxacin (NOR, 10 μg), trimethoprim + sulfamethoxazole (STX, 1.25/23.75 μg), and tobramycin (TOB, 10 μg), were placed into inoculated MHA and incubated at 37˚C for 24 hours. Afterward, the inhibition zone diameter was interpreted as susceptible, intermediate, or resistant according to the suggested CLSI breakpoint (CLSI, 2014; CLSI, 2018).

Data analysis

General characteristics or any relevant basic information, including the presence of a bacterial species resulting from a dental abscess or a severe dental infection and its antimicrobial susceptibility, were delineated and reported using descriptive analysis that involved detail on frequency, proportion, and percentage. The degree of frequency was included to summarize the occurrence of bacterial isolation from a dental abscess or severe dental infection swab. Furthermore, the results of the antimicrobial susceptibility test were analyzed and presented as a percentage. All analyzed outcomes were accomplished using Microsoft Excel program version 2011 (License ID: EWW_8b1cc31c-77a8-4ff5-9e46-b082ac54b469_64d662517f5febdc17).

RESULTS

The ensemble of 45 dogs with periapical root abscess who underwent dental extraction surgery were female (46.7%, n=21) and male (53.3%, n=24). The general characteristics of the dogs with periapical tooth abscesses who participated in this study are shown in Table 1. Most dogs were considered geriatric as their ages varied between 4 and 17 years (with a mean age of 10.6 years). In total, 49 swabs were collected with cultures yielding a total of 78 isolates. The bacterial results of this study indicated the presence of 17 different species consisting of gram-negative (64.7%, n=11) and gram-positive (35.3%, n=6) specimens, which were determined to be the pathogenic cause of periapical tooth abscesses in dogs. The bacterial species and the classification of bacteria isolated from periapical tooth abscesses are presented in Table 2. The predominant bacterial species in this study was Pseudomonas aeruginosa (34.6 %, n=27).

Overall, the isolates exhibited a variable degree of resistance to antimicrobials (Figure 1). Specifically, the bacterial isolates were determined to be resistant to clindamycin (87.2%), amoxicillin (73.0%), ampicillin (71.7%), cephalexin (57.1%), cephazolin (51.9%), amoxicillin-clavulanic acid

(48.7%), ceftiofur (41.4%), ceftriaxone (37.7%), sulfa-trimethoprim (35.9%), doxycycline (33.8%), norfloxacin (21.1%), enrofloxacin (19.2%), tobramycin (17.8%), gentamicin (14.3%), and imipenem (6.4%).

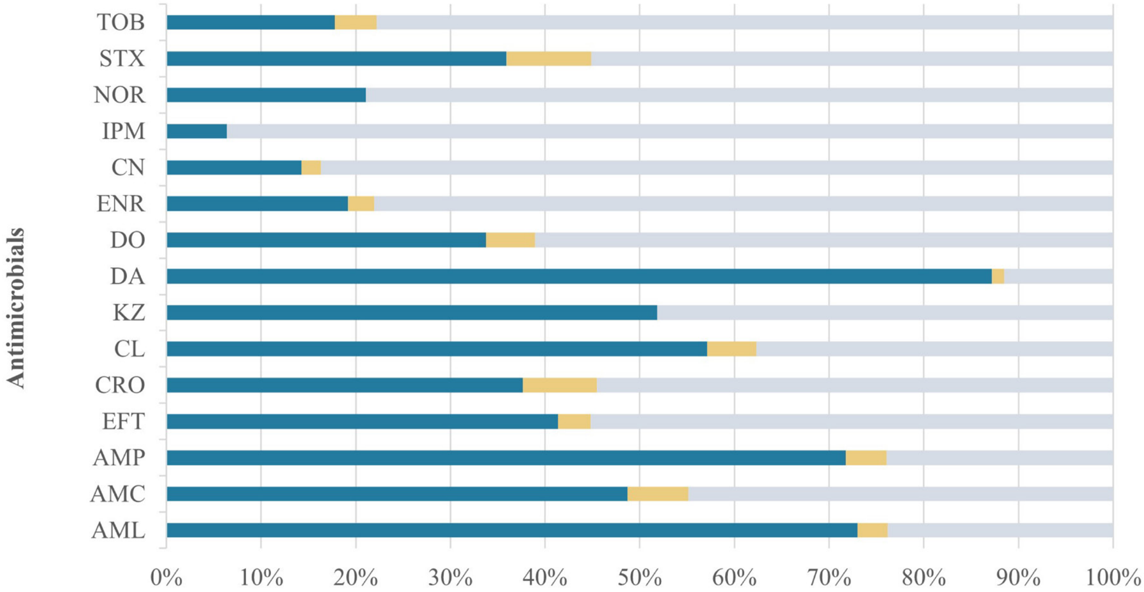
When focusing on the antimicrobial resistance of the most common isolated species, the resistance rates of each pathogen were deemed to be different, as is summarized in Table 3. *P. aeruginosa* isolates were highly resistant to clindamycin (100.0%), ampicillin (100.0%), and cephalexin (96.2%). *E. coli* was resistant to clindamycin (100.0%), amoxicillin (70.0%), and enrofloxacin (70.0%). *K. pneumoniae* demonstrated resistance to amoxicillin (10%), norfloxacin (100.0%), and clindamycin (88.9%). In this study, *P. aeruginosa*, *E. coli*, and *K. pneumoniae* isolates were resistant to amoxicillin-clavulanic acid 92.6%, 0.0%, and 22.2%, respectively. Moreover, a point of significance in this study was that several bacterial species exhibited multi-drug resistance.

Table 1 Characteristics of canine periapical tooth abscesses in this study.

Characteristics	Categories	n	(%)
Gender	Male	24	53.3
	Female	21	46.7
Age in years	<1-4	2	4.4
	5-7	7	15.6
	8-10	9	20.0
	>10	27	60.0
Breed	Toy and small	28	62.2
	Medium	17	37.8

Table 2 Classification of bacteria isolated from periapical tooth abscesses in dogs.

Bacterial isolation	Isolate (n)	Percentage (%)
Gram negative isolates		
Pseudomonas aeruginosa	27	34.6
Escherichia coli	12	15.4
Klebsiella pneumoniae	9	11.5
Acinetobacter baumannii	4	5.1
Proteus mirabilis	3	3.9
Pasteurella spp.	2	2.5
Hafnia alvei	2	2.5
Salmonella choleraesuis	1	1.3
Enterobacter taylorae	1	1.3
Providencia stuartii	1	1.3
Chromobacterium spp.	1	1.3
Gram positive isolates		
Staphylococcus aureus	6	7.7
β-streptococcus not gr. A, B or D	5	6.4
Streptococcus bovis	1	1.3
Streptococcus salivarius	1	1.3
Viridans streptococci	1	1.3
Bacillus spp.	1	1.3
Total	78	100.0



	AML	AMC	AMP	EFT	CRO	CL	KZ	DA	DO	ENR	CN	IPM	NOR	STX	TOB
% Resistance	73.0	48.7	71.7	41.4	37.7	57.1	51.9	87.2	33.8	19.2	14.3	6.4	21.1	35.9	17.8
% Intermediate	3.2	6.4	4.4	3.5	7.8	5.2	0.0	1.3	5.2	2.7	2.0	0.0	0.0	9.0	4.4
% Susceptibility	23.8	44.9	23.9	55.2	54.6	37.7	48.2	11.5	61.0	78.1	83.7	93.6	79.0	55.1	77.8

Abbreviations: amoxycillin (AML), amoxycillin-clavulanic acid (AMC), ampicillin (AMP), ceftiofur (EFT), ceftriaxone (CRO), cephalexin (CL), cephazolin (KZ), clindamycin (DA), doxycycline (DO), enrofloxacin (ENR), gentamicin (CN), imipenem (IPM), norfloxacin (NOR), sulfa-trimethoprim (STX), tobramycin (TOB).

Figure 1 Antibiogram profiles from canine periapical tooth abscess.

Table 3 Percentage of antimicrobial resistance for individual bacterial material isolated from periapical tooth abscesses in dogs.

Isolated bacteria	(n)	AML (%)	AMC (%)	AMP (%)	EFT (%)	CRO (%)	CL (%)	KZ (%)	DA (%)	DO (%)	ENR (%)	CN (%)	IPM (%)	NOR (%)	STX (%)	TOB (%)
P. aeruginosa	27	95.3	92.6	100.0	42.9	44.4	96.2	83.9	100.0	50.0	0.0	6.3	11.1	14.3	48.2	6.3
E. coli	12	70.0	0.0	66.7	40.0	8.3	16.7	22.2	100.0	66.7	70.0	45.5	0.0	50.0	33.3	22.2
K. pneumoniae	9	100.0	22.2	66.7	33.3	11.1	11.1	25.0	88.9	22.2	0.0	0.0	0.0	100.0	50.0	50.0
S. aureus	6	83.3	16.7	33.3	50.0	66.7	66.7	N/A	66.7	0.0	80.0	0.0	0.0	100.0	50.0	50.0
B-streptococcus not gr. A, B or D	5	0.0	0.0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
A. baumannii	4	75.0	25.0	0.0	100.0	75.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0
P. mirabilis	3	0.0	0.0	50.0	0.0	0.0	0.0	0.0	100.0	66.7	100.0	0.0	33.3	0.0	33.3	0.0
Pasteurella spp.	2	0.0	50.0	100.0	0.0	0.0	0.0	N/A	100.0	0.0	0.0	N/A	0.0	N/A	0.0	N/A
H. alvei	2	100.0	100.0	50.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	N/A	0.0	N/A
S. bovis	1	0.0	100.0	100.0	100.0	100.0	100.0	N/A	100.0	0.0	0.0	N/A	0.0	N/A	0.0	N/A
S. salivarius	1	0.0	0.0	N/A	100.0	100.0	100.0	100.0	100.0	0.0	100.0	N/A	0.0	100.0	100.0	N/A
S. choleraesuis	1	100.0	100.0	100.0	N/A	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
V. streptococci	1	0.0	0.0	0.0	N/A	100.0	0.0	N/A	0.00	0.0	0.0	0.0	0.0	0.0	100.0	0.0
E. taylorae	1	100.0	100.0	0.0	N/A	100.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacillus spp.	1	N/A	100.0	100.0	N/A	100.0	100.0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromobacterium spp.	1	N/A	100.0	100.0	100.0	100.0	100.0	N/A	100.0	0.0	0.0	N/A	0.0	N/A	0.0	N/A
P. stuartii	1	N/A	100.0	N/A	100.0	100.0	100.0	N/A	100.0	100.0	0.0	100.0	100.0	0.0	0.0	0.0

(n) = frequency of isolation, N/A = not applicable

DISCUSSION

This research identified the optimal bacterial species and the antimicrobial susceptibility of its isolates obtained from dogs presenting periapical tooth abscesses. The interdependence between the aerobe and the anaerobe was the synergetic pathological presence of an infection. In the beginning, aerobic bacteria grew and consumed the available oxygen in the pulp chamber. Overtime, anaerobe bacteria developed in a low oxygen environment which led to a shift in the facultative aerobe pathogen into anaerobe flora (Barclay, 1990; Siqueira et al., 2011). The pathogenesis of this disease was comprised of a polymicrobial infection (Brook et al., 1991; Baumgartner 2004) and the potential for complications that may or may not be life-threatening; therefore, the appropriate antibiotic selection was essential for effective therapy.

Periapical tooth abscesses were more common in geriatric dogs, accounting for 60.0 % of the abscesses included in this research study. The age range of the subjects in this study was similar to that of a previous study, which indicated that older dogs tended to be associated with an increased incidence of severe periodontitis (Kortegaard et al., 2008; Marshall et al., 2014). In addition, small breeds were associated with a higher prevalence of periodontal disease than large breeds (Harvey et al., 1994; Kylllar and Witter, 2005), which conformed with the results of this study.

The predominant encountered bacterial isolation in our study was facultative anaerobe bacteria. This finding correlated with the etiological agents of dental abscesses among the Lebanese population (Ghada et al., 2018). In another similar study, Head and Roos (1919) determined that the primeval bacterial isolation in human odontogenic abscesses belonged to the anaerobic bacterial group. Incidences of periapical tooth abscesses in the dogs participating in this investigation were determined to be due to severe periodontal disease. One of the major bacterial species implicated in canine periodontal disease is the *Pseudomonas* species (Manuel et al., 2014; Reggio et al., 2011). Accordingly, our study found high occurrence of *P. aeruginosa* in cases of canine dental abscesses. Meanwhile, previously published research on odontogenic abscesses in guinea pigs determined that the predominant bacterial species was *Bacteroides fragilis* (Minarikova et al., 2016). In addition, Clarke et al. (1978) reported that *S. aureus* may cause facial and mandibular abscesses in mice. *Fusobacterium nucleatum* and Prevotella species were associated with highly pathogenic bacterial incidences of mandibular and maxillary abscesses in rabbits (Tyrrell, 2002). The incidence results of *E. coli* in the dental abscesses in this study were similar to those of previous research studies, which were reported in the microflora of canine dental plaque. However, they were less prevalent in *P. aeruginosa* than was reported in our research (Patel et al., 2015). *Streptococcus* species is one of the common bacteria more often observed in humans than in pets and may be related to fundamentally different plaque compositions in humans and animals. Previous research has reported that the prevalence of *Streptococcus* in humans was as high as 67.4% (Regmi et al., 2019), while in domestic animals it was detected at a rate of 6.1-11.1% (Dent and Marsh, 1981; Patel et al., 2015.) This occurrence rate of *Streptococcus* species in animals is consistent with the rate reported in the results of this study. Bacterial isolations can be diverse and present individually according to the species of the animal or different populations of animals (Herrera et al., 2000). Additionally, different sample collection methods may affect the occurrence of bacterial species' outcomes because the intraoral cavity sampling process or the direct purulent results can lead to a low average number of isolated bacteria and a low recovery of strictly anaerobic bacterial species (Lewis et al., 1990). Thus, these causes may have led to the differences in bacterial isolation and prevalence outcomes between our results and those of previous research studies that had been conducted on other animal species or humans.

As has been previously discussed, limitations in published data on the identification of bacterial species and the testing of antimicrobial susceptibility for dental abscesses in animals has resulted in significant challenges. In a study conducted by Awoyomi and Ojo (2014) employing the use of oral swabs, it was reported that the antimicrobial susceptibility of abscesses was highly resistant to penicillin. These findings are consistent with those of our study and other recent research involving odontogenic maxillofacial abscesses in humans. It has been reported that penicillin is not usually effective against anaerobe as a first-line antibiotic (Kang and Kim, 2019). Notwithstanding, our research determined that penicillin was not the only drug that was associated with a drug-resistance problem. Importantly, clindamycin was found to be associated with a high incidence of antimicrobial resistance, as has been reported in a study conducted by Somrup et al. (2018) and Thepmanee et al. (2018). On the other hand, organism isolations in rabbits were found to be susceptible to clindamycin (100.0 %) and penicillin (96.0 %) (Tyrrell et al., 2002). The antimicrobial profile of rabbit tooth abscesses correlated with the results of a study conducted by Minarikova et al. (2016). That study determined that odontogenic abscesses in guinea pigs were also treatable by penicillin. Amoxicillin-clavulanic acid, which has been used as an empirical antibiotic in dental surgery in our area, was reported to be sensitive to only 44.9% of all bacterial isolates. In contrast, the drugs fluoroquinolone or aminoglycoside were more sensitive than certain amoxicillin-clavulanate drugs such as enrofloxacin (78.1%), norfloxacin (79.0%), and gentamycin (83.7%). Based on the results of this study, clindamycin and penicillin are among the antimicrobial drugs that may be at particular risk of following the rising trend of drug resistance with regard to the treatment of oral pathogenic bacteria associated with canine periapical root abscess or advanced periodontitis. Moreover, appropriate antibiotic use should be adjusted according to the antimicrobial susceptibility test results in the hopes of reducing the risk of antimicrobial resistance problems in the future.

Pseudomonas species can contribute to multidrug resistance in both humans and animals. The bata-lactamase intrinsic resistance pathway of *Pseudomonas* has arisen as a result of low membrane permeability and AmpC beta-lactamase production (Pechère and Köhler, 1999). The findings of this study indicated that *Pseudomonas* was highly penicillin-resistant; likewise, Eliasi et al. (2020) reported that it was highly resistant to amoxicillin-clavulanic acid (92.0%). Interestingly, the results of our study indicated that *Pseudomonas* could lead to imipenem resistance, which is consistent with the findings of Eliasi et al. (2020). Additionally, *Klebsiella* species were found to be resistant to ampicillin and amoxicillin (Pattilaya et al., 2019). This may result in their ability to carry the plasmids that produce the beta-lactamase variants of *Klebsiella*, which could then lead to penicillin-resistance (Pitout et al., 2008).

The outcomes of this investigation will help establish a database of the common pathogenic bacterial species associated with canine dental abscesses. Furthermore, the antimicrobial profiles may help veterinarians identify the appropriate antibiotic usage for treatment while awaiting the results of antimicrobial susceptibility tests. Most dental infections occur as a consequence of the presence of anaerobe and aerobe bacteria. Importantly, they can bring about more severe complications and can be difficult to manage if not appropriately treated. As has been referenced earlier in an explanation of the disease process, some studies have recommended using combined antibiotics to treat dental abscesses (Madison et al., 2008). For instance, in the antibiotic treatment of dental abscesses in guinea pigs, fluoroquinolone, in conjunction with metronidazole, has been recommended (Minarikova et al., 2016). A 7 to 10-day course of antibiotic treatment should be prescribed for dental abscesses or orofacial infections (Holmes and Pellecchia 2016). Nevertheless, the sole utilization of medicinal drugs is insufficient for the treatment of dental abscesses; the primary cause could be better ameliorated by surgical treatment with medical therapy employed as an additional form of treatment (Baskerville 1984; Capello and Lennox 2012; Jekl et al., 2013). A limitation of this study would be the small population of dogs with dental abscesses that were included. Thus, further studies may need to be conducted that include other oral diseases and increased populations of dogs. Alternatively, other animal species, such as cats, rabbits, or exotic pets, may be included in future studies to increase the population size and expand the database. The agar disk diffusion method is simple and commonly used in clinical practice in our area because all veterinarians can interpret the results, the cost is not high, and some flexibility exists in determining the sensitivity of the drug testing (Jorgensen and Ferraro, 2009). However, there are limited available data associated with this method when compared to the Microdilution method. Microdilution method testing can provide researchers with important information on the minimum inhibitory concentration (MIC). This information can then be used to assist veterinarians in selecting the appropriate form of antimicrobial therapy and in employing the appropriate dose regimen for each patient (Rechenchoski et al., 2017). Moreover, the sample collection technique between the intra-oral and extra-oral sampling processes will require further analysis.

CONCLUSIONS

Dentoalveolar abscesses and advanced periodontitis have currently become more common in dogs and animals, as well as in humans. The most effectively isolated bacterial species that were identified in this investigation were *P. aeruginosa* (34.6%), *E. coli* (15.4%), and *K. pneumoniae* (11.5%), respectively. Based on the results of this study, a high rate of resistance was associated with the use of antibiotic drugs including clindamycin, amoxicillin, and ampicillin. Additionally, amoxicillin-clavulanate, which is often given during canine dental surgery, is known to be resistant to the bacterial pathogen in dental abscesses or for advanced periodontitis. Accordingly, the antibiotics that are susceptible to certain microorganisms, such as fluoroquinolone or aminoglycoside, should be considered for expanded use in Chiang Mai, Thailand. It is believed that this would increase the overall degree of effectiveness of the treatment. Nonetheless, antimicrobial susceptibility tests should be performed in all cases due to the increase in multiple drug resistance or the occurrence of other related complications. The findings of the present study may help researchers and veterinarians determine the most suitable form of empirical antibiotic therapy while they are waiting to identify the particular bacterial species and the results of the drug sensitivity tests.

CONFLICT of INTERESTS

None of the authors have any conflicts of interest to declare.

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AUTHOR CONTRIBUTIONS

Natcha Chawnan: Investigation, Methodology, Writing - Original Draft
Raktham Mektrirat: Methodology, Formal analysis
Nattakarn Awaiwanont: Validation, Writing - Review & Editing
Kannika Na Lampang: Data Curation
Kriangkrai Thongkorn: Conceptualization, Resources, Project administration, Writing - Review & Editing

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