

MICROBIAL BIOECENOSIS OF APICAL PERIODONTITIS IN THE ROOT CANAL SYSTEM (PART 1)

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ABSTRACT

The purpose of this review article is to assess systematically the available scientific evidence about difference in microbiota of apical periodontitis in root canals during time and its antibiotic susceptibility.

The study of publications was produced in the electronic databases such as Google Scholar, PubMed during a systematic review of the literature. Included articles contain information about microorganisms in the root canal system of different forms of apical periodontitis. The publication date criterion was selected from January 2000 to December 2012.

Overall 52 articles were reviewed. After analyzing the literature for inclusion criteria, the total number of publications has become 10.

*According to literature data, bacteria located in the apical root canal system potentially participate in the pathogenesis of acute and chronic, primary and secondary apical periodontitis. Anaerobic bacteria are dominated with similar proportion of gram-negative and gram-positive microorganisms. During twelve years there were some changes in microbiota's community. The most common ones in early 2000 were *Streptococcus* spp. and *Fusobacterium nucleatum*. Then in 2008 the leading positions were taken by *Olsenella uli*, *Eikenella corrodens* and *Porphyromonas endodontalis*. Beta-lactams, macrolides, metronidazole are the choices for antibiotic therapy of apical periodontitis, depending on its microbial biocenosis. All authors contributed equally to the writing of the article.*

KEYWORDS: microbiota, microbial biocenosis, root canal system, apical periodontitis, antibiotic susceptibility.

INTRODUCTION

Apical periodontitis is caused by bacteria infecting the necrotic root canal system [Rôças I *et al.*, 2010]. The most common complication of caries is chronic apical periodontitis. Microbiocenosis of the root canal is the main factor determining the course of this chronic inflammation. The goal for endodontic treatment is to achieve maximum sterility of the root canals, which is very important at the moment. The selection and study of the antiseptic potential of irrigants will always be the number 1 task. Bacteria colonizing the root canal are usually organized in communities similar to

biofilm structures. The endodontic bacterial communities vary in species richness and abundance depending on the different types of infection and different forms of apical periodontitis [Alves FR *et al.*, 2009; Siqueira J, 2009].

The microbiota is not homogeneous throughout the length of canal but shifts its composition from coronal to apical portion, which is dominated by obligate anaerobes, whose number increases with time [Chugal N *et al.*, 2011].

Culture and molecular studies have identified many suspected endodontic pathogens in the api-

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cal canal, including black-pigmented anaerobic rods, *Peptostreptococcus* species, *Pseudoramibacter alactolyticus*, *Treponema denticola*, *Fusobacterium nucleatum*, *Porphyromonas endodontalis*, *Filifactor alocis*, and the uncultivated phylo-type *Bacteroidetes* clone X083 [Rôças I et al., 2010]. The effect on the microbiocenosis of the root canal, the effect on pure culture and culture in association in biofilm are not the same issues in the selection of antiseptic solutions.

The purpose of this review article is to assess systematically the available scientific evidence about difference in microbiota of apical periodontitis in root canals during time and its antibiotic susceptibility [Gomes BP et al., 2004; Brescó-Salinas M et al., 2006].

MATERIALS AND METHODS

The research was written in the course of the analysis of English literature in Google Scholar and PubMed electronic databases.

Publications that met the following selection criteria were included:

- 1) Publications dated from 2000 to 2012;
- 2) Availability of studies proving the antibiotic susceptibility of apical periodontitis microbiota;
- 3) Figuring the topic of the microbial biocenosis of apical periodontitis in the root canal system.

The review didn't include publications, the title and abstract of which did not meet at least one of the presented inclusion criteria.

The studies were filtered and selected in several stages. Firstly, they were evaluated by titles. Secondly, individual documents at the first stage were additionally assessed by reading the abstracts and full-text articles. The first selection criterion was the selection of publications whose titles included at least one search term. Further, publications which are dated earlier than 2000 and later than 2012 were excluded. At the last stage, the content of the full-text versions of the selected articles was examined [Moher D et al., 2010].

Cochrane Collaboration data were used to assess the risk of bias, with tests performed at each of the selection stages [Higgins J et al., 2011]. The levels of bias were classified as follows: low risk, if all the criteria were met; moderate risk, when only one criterion was missing; high risk, if two or more criteria were missing; and unclear risk, if

there were very few details to make a judgement about a certain risk assessment.

RESULTS

Overall 52 articles were reviewed, 40 of which were from the PubMed database, 12 were from Google Scholar. After the selection according to the exclusion criteria, the total number of articles was 10. In the selected articles, the relevant data on the microbiota in root canals of apical periodontitis was analyzed.

DISCUSSION

Apical periodontitis is primarily the result of bacterial infection of the pulp and the root canal system [Chugal N et al, 2011]. It is important to determine the association of bacterial combinations with clinical signs and symptoms or treatment outcome, as well as the association of certain microorganisms with each other [Fouad A et al., 2002]. Collectively, more than 400 different microbial taxa have been identified in endodontic samples from teeth with different forms of apical periodontitis [Siqueira J, 2009].

Why is microbiota so diverse?

The apical canal presents a lower oxygen tension and larger availability of proteins and glycoproteins that are highly conducive to the establishment of anaerobic bacterial species, most of which are asaccharolytic and/or proteolytic, such as *Porphyromonas endodontalis*, *Fusobacterium nucleatum*, *Tannerella forsythia*, and *Treponema denticola* (all gram -). Some saccharolytic anaerobic species, such as *Olsenella uli* (gram +) and *Prevotella baroniae* (gram-), can also be very prevalent, and these species are expected to derive nutrients from the carbohydrate portion of glycoproteins and/or food webs established with other members of the apical microbiota. Bacteria in the apical canal compose the advance front of infection and thereby reside near an inflamed tissue area. Inflammatory exudate seeps into the apical canal and



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is possible, due to the
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will of all doctors in the world

stagnates, creating a fluid phase that provides bacteria with nutrients in the form of glycoproteins and proteins. This represents optimal conditions for establishment and growth of a highly diverse microbiota [Gomes BP et al., 2005; Rôças I et al., 2010; Sato T et al., 2012].

Primary infections

Primary infections are caused by microorganisms that colonize the necrotic pulp tissue. Bacterial named species frequently detected in primary infections, including both acute and chronic apical periodontitis, belong to diverse genera of gram-negative (*Fusobacterium*, *Dialister*, *Porphyromonas*, *Prevotella*, *Tannerella*, *Treponema*, *Campylobacter*, and *Veillonella*) and gram-positive (*Parvimonas*, *Filifactor*, *Pseudoramibacter*, *Olsenella*, *Actinomyces*, *Peptostreptococcus*, *Streptococcus*, *Propionibacterium*, and *Eubacterium*) bacteria [Chávez de Paz LE et al., 2004; Siqueira J, 2009].

The majority of primary infections which were less abundant or not identified in previously treated teeth included *Porphyromonas endodontalis* (gram-), *Parascordavia denticolens* (gram +), *Prevotella* sp.(gram-), *Dialister invisus* (gram -), and *Synergistetes* (gram -) [Chugal N et al., 2011].

Secondary infections

Secondary infections are caused by microorganisms that were not present in the primary infection, but that were introduced in the root canal at some time after professional intervention. There are some reports of involvement of gram-negative anaerobes, such as black-pigmented rods and *Fusobacterium nucleatum* (gram-) [Siqueira J, 2009].

A striking observation in the samples from secondary infections was the high prevalence of *Pseudomonas* sp. as well as *Burkholderiales* (gram -) which includes the families *Burkholderiaceae* and *Comamonadaceae* [Chugal N et al., 2011].

Correlation of microbial biocenosis and apical periodontitis forms

One important ecological factor that helps to determine the composition of the root canal microbiota includes bacterial interactions. Positive bacterial interactions enhance the survival capacity of the interacting bacteria and enable different species to coexist in habitats where neither could exist alone. Positive interactions can also result in enhanced pathogenicity due to additive or synergistic effects [Rôças I et al., 2008].

Streptococcus spp. (gram+) were the organisms most strongly associated with endodontic symptoms and with the presence of swelling. *Fusobacterium nucleatum* (gram-) was previously shown to increase the pathogenicities of other organisms in mixed culture, especially those of *Porphyromonas gingivalis* and *Prevotella intermedia* (gram -). *Bacteroides forsythus* (gram-) and the spirochete *Treponema denticola* (gram-) were always associated with one or more members of the black-pigmented gram-negative rods. These two organisms (together with *Porphyromonas gingivalis*) have been called the “red complex” bacteria because of their strong association with severe forms of periodontal disease [Fouad A et al., 2002].

Treponema denticola was detected in 11 of 21 cases (52.4%), regardless of the presence or absence of symptoms. Since this spirochete was found in a relatively high percentage of the endodontic infections examined and because it is a pathogenic microorganism involved in periodontal diseases, there are reasons to believe that *T. denticola* can also participate in the pathogenesis of periradicular lesions of endodontic origin [Favieri A et al., 2000].

T. denticola, *T. socranskii*, and *T. maltophilum*, in decreasing order of prevalence, are frequently found in different forms of apical periodontitis [Sakamoto M et al., 2009].

Acute endodontic periodontitis

Strict anaerobes and microaerophiles were the dominant bacteria in 82% (14 of 17) of the cases. The genera of bacteria most frequently encountered were *Prevotella* (gram -) and *Streptococcus* (gram+). The frequency of uncultured *Prevotella* clone PUS9.180 suggests the possible key role of this *Prevotella* species in acute endodontic infections [Khemaleelakul S et al., 2002].

Fusobacterium nucleatum (gram-) has been frequently identified in acute endodontic infections. *Firmicutes* (52%) – gram+, *Fusobacteria* (17%) and *Bacteroidetes* (13%) were the most abundant in acute infections [Jungermann GB et al., 2011; Santos A et al., 2011].

Chronic apical periodontitis

The most prevalent taxa were *Olsenella uli* (74%) – gram+, *Eikenella corrodens* (63%) gram-, *Porphyromonas endodontalis* (56%) gram-, *Peptostreptococcus anaerobius* (54%) – gram+, and *Bac-*

teroidetes oral clone X083 (51%) gram -. *Olsenella uli* was present in about three-fourths of the samples, indicating that this species is a very common member of the microbiota associated with chronic apical periodontitis. *Dialister invisus* (gram-) was originally found in infected root canals of teeth with chronic apical periodontitis [Rôças I et al., 2008].

Firmicutes (59%), Bacteroidetes (14%) and Actinobacteria (10%) were the most abundant in chronic infections [Santos A et al., 2011].

Evolution of the apical periodontitis microbiota for 12 years

The most common microorganisms from 2000 to 2006 were *Streptococcus* spp. (gram+), *Fusobacterium nucleatum*, *Porphyromonas gingivalis*, *Treponema denticola*, *Prevotella*, *Bacteroides forsythus* (all gram -) [Khemaleelakul S et al., 2002; Favieri A et al., 2000; Fouad A et al., 2002].

From 2006 to 2012 *Olsenella uli* with high percentage (76%) – gram +, *Eikenella corrodens*, *Porphyromonas endodontalis*, Bacteroidetes, *Tannerella forsythia*, *Dialister invisus*, *Fusobacterium nucleatum* (all gram -) [Rôças I et al., 2008; Siqueira J, 2009; Sakamoto M et al., 2009; Rôças I et al., 2010; Chugal N et al., 2011; Santos A et al., 2011].

Antibiotic susceptibility

Penicillin V possesses antimicrobial activity against the majority of bacteria isolated from acute endodontic infections. However, if penicillin V therapy has failed to be effective, the combination of penicillin V with metronidazole or amoxicillin with clavulanic acid is recommended [Khemaleelakul S et al., 2002].

Metronidazole, with its narrow spectrum of activity mainly targeting strictly anaerobic bacteria, has been reported in several studies as an effective agent for treating refractory periodontitis involv-

ing *P. gingivalis* and/or *P. intermedia* [Bidault P et al., 2007]. Switching to clindamycin is another good alternative [Khemaleelakul S et al., 2002].

The tetracyclines, including doxycycline and minocycline, are active against important periodontal pathogens such as *A. actinomycetemcomitans*. Clindamycin is effective against gram-positive cocci and gram-negative anaerobic rods, but has very little impact on *A. Actinomycetemcomitans*. Ciprofloxacin is effective against several periodontal pathogens, including *A. actinomycetemcomitans* [Bidault P et al., 2007].

CONCLUSION

Microorganisms infecting the dental root canal system play an unequivocal role as causative agents of apical periodontitis. It is reasonable to realize that disease severity, based on intensity of signs and symptoms, or response to treatment may be related to the bacterial community composition. Necrotic root canals are typically polymicrobial, with nearly equal proportions of Gram-positive and Gram-negative bacteria, and are dominated by anaerobic bacteria.

There were some changes of microbial bioecosis of apical periodontitis in root canal system during twelve years. The leading positions of *Streptococcus* spp., *Fusobacterium nucleatum* from early 2000 were given to *Olsenella uli*, *Eikenella corrodens* and *Porphyromonas endodontalis* in 2008. However, the equal proportion of gram-positive and gram-negative microorganisms hasn't changed.

The main antibiotic therapy includes amoxicillin with clavulanic acid (or penicillin V), metronidazole, clindamycin and ciprofloxacin, depending on the microbiota.

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