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Short Communication

Microbiology of Endodontic Infections

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Abstract

Root canal system acts as a 'privileged sanctuary' for the growth and survival of endodontic microbiota. This is attributed to the special environment which the microbes get inside the root canals and several other associated factors. Although a variety of microbes have been isolated from the root canal system, bacteria are the most common ones found to be associated with Endodontic infections. This article gives an in-depth view of the microbiology involved in endodontic infections during its different stages.

Keywords: Bacteria, Endodontic, Infection, Microbiology

Introduction

Microorganisms play an unequivocal role in infecting root canal system. Endodontic infections are different from the other oral infections in the fact that they occur in an environment which is closed to begin with since the root canal system is an enclosed one, surrounded by hard tissues all around [1,2]. Most of the diseases of dental pulp and periradicular tissues are associated with microorganisms [3]. Endodontic infections occur and progress when the root canal system gets exposed to the oral environment by one reason or the other and simultaneously when there is fall in the body's immune response [4]. To begin with, the microbes are confined to the intra-radicular region when the ingress is from a carious lesion or a traumatic injury to the coronal tooth structure. However, the issue if not taken care of, ultimately leads to the egress of pathogens and their by-products from the apical foramen to the periradicular tissues.

In total, bacteria detected from the oral cavity fall into 13 separate phyla, namely, Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, Spirochaetes, Fusobacteria, Synergistes, SR1, TM7, Chloroflexi, Deinococcus, Acidobacteria, and Cyanobacteria. The prevalent ones from each of these phyla are shown in Table 1 [4].

Microbes in Primary Intraradicular Infections

Primary intraradicular infection refers to the infection of the root canal system from the microbes which have entered the exposed pulp tissue from the oral cavity

Bacterial phyla in endodontic infections	Common representatives species/phylotypes
Firmicutes	Dialister spp., Filifactor alocis, Parvimonas micra, Pseudoramibacter alactolyticus, Enterococcus faecalis, Eubacterium spp., Mogibacterium spp., Streptococcus spp., Lachnospiraceae spp.,Veillonella parvula, Lactobacillus spp., Catonella morbi, Gemella morbillorum, Selenomonas spp., Peptostreptococcus spp.
Actinobacteria	Olsenella uli, Actinomyces spp., Propionibacterium acnes, Propionibacterium propionicum, Slackia exigua
Synergistes	Clone BA121, clone W090
Spirochaetes	Treponema denticola, Treponema socranskii, Treponema maltophilum, Treponema parvum
Fusobacteri	Fusobacterium nucleatum
Proteobacteria	Eikenella corrodens, Campylobacter rectus, Campylobacter gracilis
TM7	Clone I025
SR1	Clone X112
Bacteroidetes	Tannerella forsythia, Porphyromonas endodontalis, Porphyromonas gingivalis,Prevotella spp., clone X083

Table 1: Commonly found bacterial phyla in endodontic infections

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MAIN GROUP OF BACTERIA	SPECIES
Black pigmented Bacteria (a) saccharolytic species – Prevotella (b) asaccharolytic species -Porphyromonas.	Prevotella species include • Prevotella intermedia • Prevotella nigrescens • Prevotella tannerae • Prevotella multissacharivorax • Prevotella baroniae • Prevotella denticola Porphyromonas species include: • Porphyromonas endodontalis • Porphyromonas gingivalis
Tannerella forsythia	
Dialister	• Dialister pneumosintes • Dialister invisus
Fusobacterium	• Fusobacterium nucleatum • Fusobacterium periodonticum
Spirochetes	• Treponema denticola • Treponema sacranskii • Treponema parvum • Treponema maltophilum • Treponema lecithinolyticum
Gram positive anaerobic rods	• Pseudoramibacter alactolyticus • Filifactor alocis • Actinomyces spp. • Propionibacterium propionicum • Olsenella spp. • Slackia exigua • Mogibacterium timidum • Eubacterium spp.
Gram positive cocci	• Parvimonas micra • Streptococcus anginosus, • Streptococcus mitis, • Streptococcus sanguinis • Enterococcus faecalis.
Campylobacter spp.	• Campylobacter rectus • Campylobacter gracilis • Catonella morbic • Veillonella parvula
	• Eikenella corrodens • Granulicatella adiacens • Neisseria mucosa • Centipeda periodontii • Gemella morbillorum • Capnocytophaga gingivalis • Corynebacterium matruchotii • Bifidobacterium dentium • Anaerobic lactobacilli.

Table 2: Bacteria causing primary Intraradicular infections

and further get colonized. This occurs as a result of carious or traumatic exposure of coronal pulp or any other breach in the hard tissue integrity of the tooth structure. Microbes, once proliferated, can lead to acute or chronic condition, depending on their virulence and host tissue defense mechanism. Majority of the microbes in this condition are anaerobes, comprising of 10 to 30 species *per* canal. Total bacterial counts may vary from 10^3 to 10^8 cells *per* infected canal [4].

Major bacterial groups and species that are responsible for primary intraradicular infection are summarized in Table 2 [5].

In addition, there are certain phylotypes which usually remain unrecognized but have been reported to play some role in pathogenesis of apical periodontitis are Prevotellaoral clone PUS 9.180, Eubacterium oral clone BP 1-89**,** Dialister oral clone BSO16, Migasphaera oral clone BSO16,Solobacterium etc. [4].

Other than bacteria, there are other microbes which have an important role to play in primary intraradicular infections such as Archaea, Viruses and Fungi.

Archaea are a group of prokaryotes which are different from bacteria and are characterized by a special feature of being able to survive even in the extreme of environments and hence are at times referred as Extremophiles. In this group of microbes, the ones having a role to play in causing chronic apical periodontitis are Methanogenic archaea.

Of all the Viruses which have been found to be associated with root canal system are Human Immunodeficiency Virus and Herpes viruses. Among the Herpes spp., the human cytomegalovirus and Epstein- Barr virus may have a role in the pathogenesis of apical periodontitis [6].

From all the yeasts, it is the Genus Candida and the family Saccharomycetaceae which have a significant role to play in oral infections. According to Grossman, 17% of infected root canals may contain Candida species. As per the literature, C albicans and S. cerevisiae have been found to be associated with Endodontic infections [7,8].

Microbes in Secondary Intraradicular Infections

Secondary intraradicular infection refers to the infection which occurs inside the root canal system after the treatment of the affected tooth has been initiated [8]. This usually happens due to introduction of microbes into the root canal system during endodontic therapy especially in cases where the tooth is left open for one reason or the other, leakage from temporary fillings during inter-appointment periods, coronal leakage from defective permanent restoration etc.

During this phase certain more potent microbes enter into the root canal system from the oral cavity leading to severe secondary infection. Also, at times, the bacteria which were lying in a dormant state otherwise in the canals become more aggressive due to change in the local environment. Certain bacteria like enterococcus feacalis enter into the dentinal tubules and evade the action of all antimicrobial components and medicaments. These bacteria survive there for years together because of their unique physiological characteristics and become active at a later stage, leading to persistent endodontic infection. Siqueira and Rocas studied root canal samples with persistent periradicular lesions by the means of PCR. They concluded that E.faecalis was most prevelant bacterial species (77%) and C.albicans was isolated in 9% of the samples [9].

Major bacterial species responsible for secondary infections are summarized in the given Table 3 [6].

Gram negative anaerobic rods	• Fusobacterium nucleatum • Prevotella spp. • Campylobacter rectus
Gram positive bacteria	• Streptococcus gordonii, • Streptococcus mitis • Streptococcus anginosus, • Streptococcus oralis • Lactobacillus paracasei • Lactobacillus acidophilus • Staphylococci • E. faecalis • Olsenella uli • Parvimonas micra • Pseudoramibacter alactolyticus • Propionibacterium spp. • Actinomyces spp. • Bifidobacterium spp. • Eubacterium spp.

Table 3: Bacteria causing secondary intraradicular infections

Bacteriology before Obturation

It is essential to analyze the quality and quantity of bacteria before obturation of the root canal system to evaluate the efficacy of the cleaning and shaping procedure. It not only helps to self-evaluate the productiveness of mechanical instrumentation done but also the antimicrobial efficiency of irrigating solutions used during the procedure. Though this protocol is not clinically feasible during each case of endodontic therapy but it has a definitive academic role while testing various instruments and irrigating solution which are launched new in the dental profession from time to time. In severe situations with persistent infections, this protocol is performed in clinical cases too.

It has been observed that an average of 1 to 5 bacterial species have been found in the root canals after completion of cleaning and shaping procedure and the counts were found to be reaching up to 10^2 to 10^5 cells *per* canal [4].

It has been observed that the microbes which persist after the chemo-mechanical preparation are most commonly anaerobic rods such as F. nucleatum, Prevotella species, and C. rectus or Gram-positive bacteria such as Streptococci (S. mitis, S. gordonii, S. anginosus, S. sanguinis, and S. oralis), P. micra, Actinomyces species (A. israelii and A. odontolyticus), Propionibacterium species (P. acnes and P. propionicum), P. alactolyticus, Lactobacilli (L. paracasei and L. acidophilus) and E. faecalis [4].

Microbes in Endodontically Treated Teeth

It is a well-established fact that despite flowing the standard protocol of endodontic treatment, some cases still fail. These failures are due to multiple reasons but the microbiological factors have a significant role to play. From all the cases which report back with pain and infection after the endodntic therapy, it has been observed that E. faecalis is the most commonly found, with prevalence values reaching up to 90% [4].Other bacteria isolated in similar cases are streptococci P. alactolyticus, P. propionicum, F. alocis, D. pneumosintes, and D. invisus [4].

As far as the fungi are concerned, it is the Candida species that have been most commonly seen to be involved in as many as 18% of the cases [10]. To be more specific, it has been observed that C. albicans is the most commonly detected fungal species in re-treatment cases [8].

Beyond the Border: Extraradicular Infections

Extraradicular infection refers to the infection of the periradicular region. The infection can be either dependent or may be independent of intraradicular infections. While most of these infections are a sequel to the intraradicular ones, apical actinomycosis, caused by Actinomyces species is an example of extraradicular infection independent of the intraradicular infections.

Species which have been reported by many studies to be involved in the extrardicular infections include: Actinomyces species (A. israelii, A. naeslundii, A. odontolyticus, A. viscosus), P. acnes, P. propionicum, P. gingivalis,P. intermedia, Prevotella oralis, P. micra, and F. nucleatum [4].

Microbes in Endodontic Flare-Ups

The mid treatment flare ups during endodontic therapy are a night mare for the treating dentist because at times these flare ups exhibit in the form of an acute emergency, expressing itself in the form of pain or swelling or both [11]. The flare ups can be immediate post obturation also and the etiology in both the cases can be mechanical, chemical or microbial injury to the pulp and periradicular tissues. Of all the mentioned factors, bacteriological ones have definitely a major role to play.

Chavez de Paz examined root canal microbiota and revealed F. nucleatum to be associated with flare-up pain and swelling. Other microbes isolated with flare-ups were Gram negative obligate anaerobic rods belonging to the genera Prevotella and Prophyromonas (Black pigmented bacteria) [12].

Chavez de Paz suggested that the combination of F.nucleatum, Prevotella spp. and Prophyromonas species may provide a risk factor for endodontic flare-ups by acting in synergy to increase the intensity of periapical inflammatory reaction [8]. In a study done by Sundqvist, et al. in necrotic dental pulp, a relationship was established between certain microorganisms and painful teeth. In all cases of flare-up, an anaerobic gram negative rod, Bacteroides melaninogenicus was found [13].

A new bacterial species has also been identified with failed endodontic treatment in two patients with failed endodontic treatment and persistent signs and symptoms. The bacteria were similar to each other and were classified as Actinomyces radicidentis [13].

Conclusion

It is now well established that bacteria are responsible for the development of pulpal and periradicular diseases and the presence of bacteria inside the root canal system or periapical tissue can alter the success rate of endodontic treatment. Therefore, for a successful treatment, the canals should be thoroughly disinfected and rendered bacteria free prior to obturation for which a thorough understanding of microbes responsible for endodontic infection is a must.

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