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A Black Pigmented Strain: Porphyromonas Endodontalis and Its Role in Endodontics

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Introduction: Anaerobic gram-negative bacteria play essential role in the development of periodontal and endodontic diseases. Anaerobic, black-pigmented Porphyromonas endodontalis (previously Bacteroides endodontalis) is a rod of Gram-negative bacteria linked to endodontic inflammation.
Materials and Methods: Using keywords like P. endodontalis, periapical periodontitis, gram-negative anaerobic bacteria pigmented in black, endodontic inflammation and more, pertinent publications about P. endodontalis were gathered and chosen from PubMed, google scholar.
Results: It has been identified from submucous abscesses of endodontic origin as well as infected dental root canals. It has been observed that the presence of P. endodontalis in infected dental root canals is associated with acute infection symptoms. The present paper is to review and evaluate the literature on P. endodontalis, including information on virulence factor, diet, epidemiology, detection, and treatment.

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1. INTRODUCTION

An essential part of endodontic and periodontal diseases is played by gram-negative anaerobic bacteria [1,2]. These microbes are arranged into intricate communities that are adhered to a surface and shielded from harm by a viscous coating called a biofilm, which is made up of a polysaccharide and protein matrix. It offers defense against antimicrobial agents, host defenses, hostile microbes, and environmental stress [3].

Studies on humans and animals have clearly demonstrated the fundamental role bacteria play in the development and maintenance of peri-radicular lesions. The first person to propose that bacteria could play a role in both pulpal and peri-radicular illnesses was Miller [4] in 1894. The presence of bacteria is a precondition for a successful resolution of endodontic problems, as demonstrated by later studies by Sundqvist [5] in 1976 and Kakehashi et al. [6] in 1965.

Despite the fact that the oral microbiota is known to consist of over 400 different bacterial species, only a small number of these species are able to colonize the root canal system and cause pulpal and periradicular inflammation. The genera Eubacterium, Peptostreptococcus, Propionibacterium, Actinomyces, Fusobacterium, Prevotella, Porphyromonas, and Streptococcus are typically the species isolated from primary root canal infections . Certain indications and symptoms of endodontic infections have been linked to certain of these bacteria. Porphyromonas endodontitalis is one of them that has been linked to infections that cause symptoms frequently [7,8].

Pulp necrosis and endodontic infections are linked to P. endodontalis (Pe), originally known as Bacteroides endodontalis, a rod-shaped, gram-negative, anaerobic bacteria with black pigmentation . Acute symptoms including pain, swelling in reaction to a purulent inflammation, and pain upon percussion or probing are caused by P. endodontalis colonization in the periapical lesions. P. endodontalis is one of the five to seven species linked to endodontic infection; it is often linked to the initial infection of the root canal, that is, an untreated root canal. P. endodontalis's lipopolysaccharides cause the release of inflammatory cytokines. It is a critical bacterium in the regulation of periapical disease and a significant endodontic pathogen due to the potential for bone resorption caused by the ensuing inflammation [9,10,11].

It's critical to understand the underlying causes of endodontic infections in order to treat them appropriately. Examining the literature on P. endodontalis and its virulence factors, epidemiology, and therapy is the aim of this review.

2. VIRULENCE FACTOR OF PORPHYROMONAS ENDODONTALIS

The lipopolysaccharide endotoxin is a significant virulence factor of P. endodontalis, as it is essential for inducing the release of proinflammatory cytokines and causing bone degradation. Since lipopolysaccharides prevent osteoblast development and bone mineralization, they constitute a significant portion of the outer membrane of gram-negative bacteria and are strong inducers of bone resorption. Lipopolysaccharides also cause osteoblasts to produce lipid immunomodulators and inflammatory cytokines, including prostaglandin E2, interleukins (IL), and tumor necrosis factor-a (TNF-a). These elements contribute to the suppression of bone growth and alveolar bone resorption [12].

Around 90% of pus samples from acute abscesses and many infected root canals contain P. endodontalis lipopolysaccharides, which indicates that the bacteria is a strong stimulant of inflammatory cytokines involved in bone resorption and abscess formation. Iron-binding proteins, fimbriae, capsules, outer membrane proteins, proteinases, cytotoxic metabolic products, and oxygen resistance protein are some of P. endodontalis's additional virulence factors [13].

3. PATHOGENECITY

Anaerobic mixed infections in early experiments using bacteria from necrotic tooth pulps have demonstrated the crucial role played by black-pigmented anaerobic species, such as P. endodontalis. It was discovered that the presence of black-pigmenting anaerobic rods was a prerequisite for transmissible diseases. In contrast to P. gingivalis, P. endodontalis has demonstrated comparatively poor pathogenicity in experimental monoinfections. In the mouse model, subcutaneous P. endodontalis inoculation causes an inflammatory lesion to spread without developing an abscess or phlegmonous lesions. Some evidence suggests that the P. endodontalis species varies in pathogenicity.

4. SEROLOGICAL CHARACTERISTICS

While P. endodontalis and P. gingivalis do not share common antigens, P. asac-charolytica and P. endodontalis might. When antiserum is raised against itself, P. endodontalis becomes agglutinated. We have demonstrated the presence of three serotypes using whole cell agglutination: OK, OK, and O,K. It was proposed that the serological variations could be attributed to the existence of distinct types of capsules or the lack of capsular material. Using monoclonal antibodies, Hanazawa and colleagues have recently verified that the O.K. serotype has a serospecific antigen. The sonicated extract, the whole membrane fraction, and the capsular material of the O and K strains all contained this antigen. The pure lipopolysaccharide of the cells, however, elicited no reaction from the monoclonal antibody. Furthermore, Hanazawa (personal communication) reported that no reaction was seen with the OK strain. These findings support the theory that distinct capsular layers within the bacterial cells serve as the foundation for the various P. endodontalis serotypes [14].

5. ANTIMICROBIAL SUSCEPTIBILITY

The tested P. endodontalis strains are sensitive to penicillin, cephalosporins, clindamycin, erythromycin, metronidazole, bacitracin, and tetracyclines, but resistant to the aminoglycosides such as kanamycin, neomycin, and gentamicin. In conclusion, anaerobic mixed infections of the endodontium seem to involve P. endodontalis. It appears reasonable to conclude that P. endodontalis plays a crucial role in severe forms of dental root canal infections based on the relationship with clinical symptoms, the outcomes of experimental mixed infections with P. endodontalis, and the presence of numerous significant virulence factors [5,15].

6. NUTRITION TO THE BACTERIA

Understanding the microbiota that inhabits the apical third of the root canal system is crucial for the effectiveness of endodontic therapy since this region is thought to be crucial [16]. Within the root canal, the microbes occupy advantageous and strategic locations. In these environments, they are shielded from the effects of host defense chemicals and cells (phagocytes, complement), but they still need to locate food or other resources to survive. The apical portion of the root canal, in particular, and its close proximity to the host's living tissues create a distinct microenvironmental niche that is occupied by specific bacterial strains [17]. Strictly anaerobic bacteria, including P. endodontalis, are more likely to establish themselves at the apical portion of the root canal due to the low oxygen tension there. Furthermore, bacteria in the apical portion of the root canal can get different kinds of nutrients from the tissue fluids and the inflammatory exudate that is present at the border between the infected root canal and the periradicular tissues [18]. This could encourage the growth of bacteria that primarily rely on proteins for nourishment, which would explain why some bacteria—like Porphyromonas, Peptostreptococcus, Prevotella, and Fusobacterium—are frequently mentioned as being a part of the microbiota in these regions. Additional nutrients like vitamins, hormones, and blood components could be supplied by the host [19].

7. EPIDEMOLOGY

In teeth with apical periodontitis, P. endodontalis (59%), Fusobacterium nucleatum (55%), Dialister invisus (50%), Olsenella uli (49%), and Parvimonas micra (48%) are the bacteria that are typically found in root canal samples. Conversely, P. endodontalis (63%), D. invisus (58%), O. uli (56%), and F. nucleatum (51%), on the other hand, are the bacteria most commonly found in asymptomatic teeth; in abscesses, on the other hand, these are F. nucleatum (60%), P. endodontalis (53%), P. micra (51%), and Streptococcus (45%). P. endodontalis is found in symptomatic individuals at a much higher rate than in asymptomatic cases. Purulent exudates are intimately linked to P. endodontalis, which has a 22.2% frequency in secondary or persistent endodontic lesions [15,20].

When endodontic therapy fails, black-pigmented bacteria are found in teeth with necrotic pulp more often than in teeth without it. Both symptomatic and asymptomatic teeth with secondary endodontic infections have been shown to harbor black-pigmented bacteria. It's possible that some species present in both asymptomatic and symptomatic infections are unrelated to the symptoms, indicating that the development of acute signs and symptoms is contingent upon the pathogenicity and synergy of black-pigmented bacteria, like P. endodontalis, with other bacterial species, as well as the quantity of bacteria in the root canal [20,21].

8. DIAGNOSIS

The polymerase chain reaction (PCR) guided by 16S rDNA PCR-based identification studies have indicated a higher incidence of black-pigmented bacteria in endodontic infections compared to culture studies [20]. Black-pigmented bacteria has been utilized to detect primary endodontic infections and in teeth with failed endodontic therapy . The limited detection of P. endodontalis using culture technique may be attributed to the loss of hard-to-grow bacteria. PCR analysis is a more sensitive and effective means of detecting black-pigmented species than culture methods [22,23].

9. TREATMENT

Complete eradication of bacteria in the root canals is challenging due to the diverse morphology of the root canals, which includes fins, isthmuses, and accessory canals. In the course of treating the root canal, different irrigating solutions are utilized in addition to mechanical cleaning [24]. These include 17% EDTA, chlorhexidine and sodium hypochlorite, which is the most effective antimicrobial irrigator. There might still be some germs in the root, though.

Therefore, in order to bury any remaining bacteria and subsequently eradicate them, a strong seal of the duct area is necessary. Antibacterial root canal sealants are essential, efficient, and offer numerous benefits in the management of infections because they stop germs from returning to the canal and deactivate any leftovers after filling [25]. When the concentration of the sealer cement AH Plus (Dentsply) or Sealapex (Kerr) is greater than 6.4 mg/ml, P. endodontalis growth is significantly suppressed. Through bisphenol A, AH plus, an epoxy resin-based sealer, demonstrates potent antibacterial action against P. gingivalis and P. endodontalis [25,26].

As the host defense system can never completely remove the infection, eradicating a bacteria like P. endodontalis requires both, perfect chemo-mechanical debridement with adequate root canal sealing apically and coronally.

Antibiotics are not necessary for the great majority of endodontic infections that are treated [27].

10. CONCLUSION

Since P. endodontalis is an anaerobic bacterium with low nutritional needs, it is challenging to eradicate. Lipopolysaccharides are the primary cause of pathogenicity. The evaluation of epidemiological features is challenging due to the synergy with other bacteria. The most effective treatment for getting rid of P. endodontalis is a mechanical-chemical cleaning and sealing.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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