Revisiting periodontal microbiology

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Article Info

ISSN (online): 2582-8940
Volume: 04
Issue: 01
January-March 2023
Received: 16-11-2022;
Accepted: 03-12-2022
Page No: 01-04

Abstract
Periodontal diseases are inflammatory and destructive diseases of the dentogingival complex associated with specific periodontal pathogens inhabiting periodontal pockets. Periodontal diseases lead to damage of the periodontal tissues supporting the teeth (bone and connective tissue) and affect the quality of life of the affected individuals: poor alimentation, tooth loss, social and financial problems. Although it is generally considered that the disease has multifactorial etiology, data show that some specific Gram-negative microorganisms in the subgingival plaque biofilm play a major role in the initiation and progression of periodontitis. Porphyromonas gingivalis, Treponema denticola and Tannerella forsythia form a consortium in the subgingival biofilm and are regarded as the principal periodontopathogenic bacteria. Other microorganisms that have been implicated as predominant species in the disease process which are also discussed in this review.

Keywords: Periodontitis, dental microbiology, oral microbes, periodontal pockets, oral biofilm

Introduction

Periodontitis is a polymicrobial disease caused by complex interactions between distinct pathogens in a biofilm resulting in the destruction of periodontal tissues. It seems evident that unknown microorganisms might be involved in onset or progression of periodontitis. For many decades, research in the field of oral microbiology failed to identify certain subgingival microbiota due to technical limitations but, using molecular approaches and sequencing techniques, it became feasible to reveal the existence of new periodontal pathogens. Therefore, it is evident that in addition to conventional periodontal pathogens, other microbes might be involved in onset and progression of periodontitis. The novel pathogens enlisted under periodontal phylogeny include *Cryptobacterium curtum*, *Dialister pneumosintes*, *Filifactor alocis*, *Mitsuokella dentalis*, *Slackia exigua*, *Selenomonas sputigena*, *Solobacterium moorei*, *Treponema lecithinolyticum*, and *Synergistes*. Periodontal disease is the commonest oral disease affecting about 30% of the human population [1]. The involvement of the periodontal pathogens is being more and more realized. These pathogens constitute the "Oral microbiome", a term that was coined 'to emphasize the ecological community consisting of the commensal, symbiotic, and pathogenic µ-organisms that are present in the oral cavity and are capable of determining oral health and disease' [2]. Studies concerning the epidemiology in dentistry have showed that dental caries and periodontal diseases are the most prevalent pathologies that affect the oral cavity [3].

*T*he environmental diversity of the oral cavity promotes colonization of distinct microbial communities. The breadth of this bacterial diversity was studied by many scientists through culture-independent studies. They implicated specific species or phylotypes in various oral diseases such as chronic periodontitis, necrotizing ulcerative diseases, and aggressive periodontitis. Periodontitis is a polymicrobial disease caused by complex interactions between distinct pathogens in a biofilm resulting in the destruction of periodontal tissues [4]. The prime step in the treatment of periodontal disease is identification of the key pathogen. The establishment of an organism as a true pathogen is based on its high prevalence at disease sites and its reduction or absence with regression of disease. Since decades research in the field of oral microbiology failed to reveal complete taxonomic data to the species level by mere culture techniques. Due to these technical difficulties, the emergence of molecular and immunologic tests such as PCR, DNA probes, and immunoassays made research to progress toward the identification of uncultivable taxons also [5].

Periodontal microbiology

Periodontal pockets accommodate a multitude of bacterial phylotypes that make it difficult to differentiate between mere commensals and true pathogens. The profiles of these bacterial species differed on different oral surfaces, and this could be the reason why some bacteria remain unidentified [2, 6, 7]. A few of these include, *Filifactor alocis*, Selenomonas, *Synergistes*, and *Dialister pneumosintes* that have been identified in a number of independent studies. Hence, the role of these novel pathogens in periodontal pathogenesis needs attention [8].

The oral biofilm primarily comprises of microbes andhost proteins adhering to the teeth immediately after oralprophylaxis. The healthy gingival sulcus has flora predominantly consisting of *Gram positive cocci*, such as *Streptococcus spp*, and *Actinomuces sp* in the equal concentrations [5]. A transition inthe composition of the gingival sulcus from gram-positive, facultative type, µ-organisms with fermentation potential to predominantly gram-negative, anaerobic in nature, chemo-organotrophic, organisms and with proteolysis potential leads to the progression of the periodontal disease [2, 3].

Subsequently, the plaque undergoes maturation that leads to a micro flora having more of the anaerobic-organisms which are facultative, spirochetes and motile rods. With increase in the severity of the disease, the strict anaerobic, Gram-negative and motile organisms increase proportionately. The periodontal disease progresses from the slow, chronic, progressive destruction to short and acute sudden bursts that vary inintensity and duration [5].

The levels of the enzyme alkaline phosphatase have proved to be a good indicator gingival health and disease. When their levels were compared around healthy and diseased implants, the results indicate an increase in the enzyme levels around diseased implants when compared to the healthy implants, which can also lead to increase in periodontal pathogens.

Recent developments in periodontal microbiology

Microbiologists have recently discovered an unexpectedly high level of coordinated multi-cellular behaviors which have made the perception that biofilms are like "cities" of organisms. The bio-films are regulated by the signaling mechanism such as the "quorum sensing", in which, the bacterial cells do communication with each other by releasing, sensing and responding to small diffusible signal molecules. As communication is the major factor for inter pricing discrepancies, the biofilms forming bacteria adopt specialized roles and communicate with one another [6].

Research over a period of many years on the sub- gingival microflora has helped in classifying microorganisms into certainform of color complexes that have variation from red two yellow as per their composition. Red Complex Is Extremely pathogenic and yellow is more of commensal. A number of micro-organisms that are supposed to be responsible for diseases like *Porphyromonas Endodontalis, P. denticola, Filifactor alocis, Cryptobacterium curtum, Eubacterium saphenum, Mogibacterium timidum, P. corporis, P. disiens, Peptostreptococcus Magnus, Slackiaexigua, Trep. maltophilum, Trep.sp. Smibert-3, Trep. lecithinolyticum, Trep. putidum sp. nov., Enterococcus faecalis, Escherichiacoli* and *Bartonellasp* [2, 5].

Red and orange complexes have been classified as late colonizer in the development and maturation of subgingival plaque and they have been closely related to the pathological conditions of periodontal tissue [7].

Uncontrolled diabetes has a major impact on the periodontium. The glucose content of GCF in diabetics has been shown to be elevated compared with non-diabetics. This could provide an altered source of nutrition for subgingival microorganisms and subsequently modify the proportions of certain species within the biofilm. Furthermore, the immune response to periodontal pathogens may be altered or impeded in diabetics, which could lead to the overgrowth of certain species. Advances in the understanding of biofilms indicate that there is a highly complex interplay between many different species with certain, more virulent, organisms tending to coaggregate [10].

Newer management methods

Newer drugs are available to control the progression of periodontal pathogens, especially newer combinations of tetracyclines are quite effective against the pathogens. In the current scenario, systemic drug administration is also used as an adjunct to local therapy. Doxycycline is observed to have a good impact on clearing the pathogenic flora of periodontitis, as it is well secreted thorough the gingival crevicular fluid. Further, various modalities to deliver doxycycline are also available in the market [11].

Nanotechnologies are being introduced in the field of dentistry for the control and prevention of various diseases, including periodontal diseases. The use of triclosan- or tetracycline-loaded nanoparticles has allowed scientists to develop new drug delivery systems to treat periodontal disease. Because of their homogeneous distribution, these nanoparticles can remain in contact with an affected area for an extended period. Recently developed nano materials and nanotechnology can assist in shed light on commercial applications of nano materials for the ''real" regeneration of periodontal apparatus as a whole, comprising dentine, cementum, periodontal ligaments, and bone. Tissue engineering triads and scaffolds impregnated with nanoparticles can simulate an extracellular matrix to help stimulate the creation of host tissues in animals [12].

Oral cancer and periodontal disease

Periodontal diseases are also a high-risk factor for oral cancer, and they are more common in the Indian population, where it is mostly caused by the practice of chewing tobacco related products. Chewing tobacco related products induces extended exposure of the oral mucosa, as well as abrasion of the epithelial linings. Smokeless tobacco consumption, both orally and nasally, has been linked to potentially malignant oral diseases and malignancies of the oral cavity. Tumorigenesis and inflammation caused by bacterial and viral infections, as well as inflammatory bowel illnesses, also play a major role in the development of cancer [13, 14].

Recently, the role of organisms such as *D.pneumosintes, F. alocis, T. lecithinolyticum, S. moorei, Cryptobacterium curtum, Peptostreptococcus micros* and *Fusobacterium nucleatum* have been implicated with periodontal disease. In one of the reviews by *Hajishengallis and Lamont*, polymicrobial synergy nddysbiosis model of periodontal disease was suggested which suggested that some definite species, known as the "keystone pathogens," modulate the response of the host which leads to the impairment of immunity and change the homeostatic balance in favour of dysbiosis [15, 16, 17].

It was found that the following genera of microorganisms:

Porphyromonas, Tannerella, and Eubacterium in salivary sample of periodontitis patients have shown quite abundance compared to the salivary samples of the healthy controls. This will have an impact on various periodontal treatment modalities including bone grafting, implants, and other regenerative techniques [18, 19, 20].

Recently, the biomedical informatics had been studied in connection with dental issues and new terms such as "oral genomics" etc. has been coined and used widely. It has furthered our understanding of pathogenesis and microbiology in the genomic and proteomic level, their complex networks, metabolic pathways of the initiation and progression of oral diseases. While the essential goal of bioinformatics is to improve the understanding of biological processes, various aspects of oral biology such as biomechanics, microbiology of various regions, genetic links of diseases etc. have to be integrated to it [21].

Conclusion

Research has focused on the identification of novel hidden pathogens that might contribute to the pathogenesis of periodontal disease. Inspite of advanced therapeutic modalities aimed at complete elimination of periodontal pathogens, the prevalence of periodontal diseases is increasing[22]. To develop effective therapeutic approaches, it requires identification of key and accessory pathogens and the role played by them in periodontal pathogenesis. These novel pathogens were grouped into high (*Firmicutes*), moderate (*Synergistes*, *F. alocis*, *S. sputigena*, *T. lecithinolyticum*), low (*D. pneumosintes* and *M. dentalis*) based on their association with periodontal disease [23, 24, 25]. Thus, revealing and understanding the role played by these pathogens in periodontal plethora is prudent for better prevention of periodontal disease. The evidence till date is not conclusive of any single micro-organism being implicated in the etiology of the periodontal disease but several micro-organisms might play a role in the occurrence and progression of the periodontal disease [26]. Many of the unrecognized periodontal pathogens are to be unmasked so that their possible role in the pathogenesis of the periodontal disease could be understood.

References

1. Hugoson A, Norderyd O. Has the prevalence of periodontitis changed during the last 30 years? J Clin Periodontol. 2008; 35:338-345.
2. Natarajan Prabhu Manickam, *et al*. Transmission of actinobacillus actinomycetemcomitans & porphyromonas gingivalis in periodontal diseases. Indian Journal of Public Health Research and Development. 2020; 11:777-781.
3. Jaber Aesa Alzaroug, Alshame MJ Alshame, Khaled Owidat Abdalla, Prabhu Manickam Natarajan. The Association between Teeth Loss and Oral Health Problems. Indian Journal of Forensic Medicine & Toxicology. 2021; 15(1):1893.
4. Kilian M, Chapple IL, Hannig M, Marsh PD, Meuric V, *et al*. The oral microbiome-anup date for oral health care professionals. Br Dent J. 2016; 221:657-666.
5. Teles R, Teles F, Frias-Lopez J, Paster B, Haffajee A. Lessons learnedand unlearned in periodontal microbiology. Periodontol. 2000; 62:95-162.
6. Mohanty R, Asopa SJ, Joseph MD, Singh B, Rajguru JP, *et al*. Redcomplex: Polymicrobial conglomerate in oral flora: A review. J Family Med Prim Care. 2019; 8:3480-3486.
7. Choi JU, Lee JB, Kim KH, Kim S, Seol YJ, *et al*. Comparison of Periodontopathic Bacterial Profiles of Different Periodontal Disease Severity Using Multiplex Real-Time Polymerase Chain Reaction. Diagnostics (Basel). 2020; 10:965.
8. Hajishengallis G, Lamont RJ. Beyond there dcomplex and into more complexity: The polymicrobial synergy and dysbiosis (PSD) model of periodontal disease etiology. Mol Oral Microbiol. 2012; 27:409-419.
9. Natarajan PM, Chandran CR, Prabhu P, Julius A, Prabhu P. Comparison of Enzyme Beta Glucuronidase and Alkaline Phosphatase Levels in Peri Implant Sulcular Fluid Around Healthy and Diseased Implants – A Clinical Pilot Study. Biomed Pharmacol J, 2017, 10(2).
10. Natarajan, Prabhu Manickam, Vijay Ebenezer, and Bhagyasree Nair. Dental Management of Diabetic Patients: A Review. Nveo-Natural Volatiles & Essential Oils Journal| NVEO, 2021, 360-365.
11. Natarajan Prabhu, Vidhya Rekha, Anita Murali, and Bhuminathan Swamikannu. Newer congeners of doxycycline–do they hold promise for periodontal therapy? Archives of Medical Science-Civilization Diseases. 2022; 7(1):16-23.
12. Umapathy, Vidhya Rekha, Prabhu Manickam Natarajan, C. Sumathi Jones, Bhuminathan Swamikannu WMS. Johnson V Alagarsamy, Ashequr Rahman Milon. Current trends and future perspectives on dental nanomaterials-An overview of nanotechnology strategies in dentistry. Journal of King Saud University-Science, 2022, 102231.
13. Umapathy, Vidhya Rekha, Prabhu Manickam Natarajan, and Bhuminathan Swamikannu. Comprehensive Review on Development of Early Diagnostics on Oral Cancer with a Special Focus on Biomarkers. Applied Sciences. 2022; 12(10):4926.
14. Natarajan, Prabhu Manickam, Vijay Ebenezer. Tobacco Use and Its Effect on Dental Extraction: A Review. Nveo-natural volatiles & essential oils journal| nveo, 2021, 494-496.
15. Edwards AM, Jenkinson HF, Woodward MJ, Dymock D. Binding properties and adhesion-mediating regions of the major sheath protein of *Treponema denticola* ATCC 35405. Infect Immun. 2005; 73:2891-8.
16. Aruni AW, Roy F, Fletcher HM. *Filifactor alocis* has virulence attributes that can enhance its persistence under oxidative stress conditions and mediate invasion of epithelial cells by Porphyromonas gingivalis. Infect Immun. 2011; 79:3872-86.
17. Wang Q, Jotwani R, Le J, Krauss JL, Potempa J, Coventry SC, *et al*. *Filifactor alocis* infection and inflammatory responses in the mouse subcutaneous chamber model. Infect Immun. 2014; 82:1205-12.
18. Hiranmayi KV, Sirisha K, Ramoji Rao MV, Sudhakar P. Novel Pathogens in Periodontal Microbiology. J Pharm Bioallied Sci. 2017; 9(3):155-163. doi: 10.4103/jpbs.
19. Fenno JC, Hannam PM, Leung WK, Tamura M, Uitto VJ, McBride BC. Cytopathic effects of the major surface protein and the chymotrypsinlike protease of *Treponema denticola*. Infect Immun. 1998; 66:1869-77.
20. Natarajan, Prabhu Manickam. Bone grafts in periodontal regeneration. Indian Journal of Public Health Research & Development. 2018; 9(11):289.

21. Natarajan, Prabhu Manickam. Dental Bioinformatics-Current Scope and Future perspectives. Research Journal of Pharmacy and Technology. 2022; 15(5):2351-2356.
22. Pedersen RM, Holt HM, Justesen US. *Solobacterium moorei* bacteremia: Identification, antimicrobial susceptibility, and clinical characteristics. J Clin Microbiol. 2011; 49:2766-8.
23. Vartoukian SR, Palmer RM, Wade WG. Diversity and morphology of members of the phylum synergistetes in periodontal health and disease. Appl Environ Microbiol. 2009; 75:3777-86.
24. Siqueira JF, Jr, Rôças IN. Molecular detection and identification of *Synergistes* phylotypes in primary endodontic infections. Oral Dis. 2007; 13:398-401.
25. Chen H, Liu Y, Zhang M, Wang G, Qi Z, Bridgewater L, *et al*. A *Filifactor alocis*-centered co-occurrence group associates with periodontitis across different oral habitats. Sci Rep. 2015; 5:9053.
26. Belibasakis GN, Oztürk VÖ, Emingil G, Bostanci N. *Synergistetes* cluster A in saliva is associated with periodontitis. J Periodontal Res. 2013; 48:727-32.