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EPIDEMIOLOGY, ETIOLOGY, PATHOGENESIS, CLINICAL COURSE, AND MODERN TREATMENT APPROACHES OF PERIODONTAL DISEASES IN SCHOOL-AGED CHILDREN

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Abstract: Periodontal diseases in school-aged children represent a significant and often underestimated public health concern, affecting both oral and systemic health outcomes. The prevalence of gingival and periodontal conditions in this population varies widely across regions, with epidemiological data indicating that up to 70–90% of children exhibit signs of gingival inflammation, while more severe forms of periodontitis, though less common, demonstrate increasing incidence with age and inadequate oral hygiene. The multifactorial etiology of periodontal diseases involves microbial biofilm accumulation, host immune response, genetic predisposition, hormonal fluctuations, nutritional deficiencies, and environmental influences. The pathogenesis is characterized by a complex interaction between pathogenic microorganisms and the host's immune-inflammatory response, leading to progressive destruction of periodontal tissues. Clinical manifestations range from reversible gingivitis to aggressive forms of periodontitis associated with rapid attachment loss and alveolar bone destruction. Early diagnosis remains critical, as pediatric periodontal conditions often present with subtle clinical signs but may progress rapidly without intervention. Modern treatment approaches emphasize a comprehensive strategy integrating preventive, therapeutic, and educational components. These include mechanical plaque control, antimicrobial therapy, host modulation, minimally invasive procedures, and the application of advanced technologies such as laser therapy and regenerative techniques. Preventive programs focusing on oral hygiene education and regular dental check-ups play a pivotal role in reducing disease burden.

Keywords: Periodontal diseases, children, gingivitis, periodontitis, etiology, pathogenesis, epidemiology, oral microbiota, inflammation.

Introduction: Periodontal diseases constitute a group of inflammatory conditions affecting the supporting structures of the teeth, including the gingiva, periodontal ligament, cementum, and alveolar bone. In school-aged children, these diseases are predominantly represented by gingivitis, although early-onset forms of periodontitis are increasingly recognized as clinically significant entities. Despite their high prevalence, periodontal diseases in pediatric populations are often overlooked due to their typically mild and reversible nature in early stages. However, failure to address these conditions timely may lead to irreversible tissue damage and predispose individuals to chronic periodontal pathology in adulthood.

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Epidemiological studies have consistently demonstrated that gingival inflammation is nearly ubiquitous among school-aged children, with prevalence rates ranging between 60% and 90% depending on geographic, socioeconomic, and behavioral factors. Poor oral hygiene remains the primary contributing factor, often exacerbated by inadequate awareness, limited access to dental care, and insufficient parental supervision. Additionally, systemic and local factors such as malocclusion, mouth breathing, and dental caries contribute to plaque retention and subsequent periodontal inflammation.

The significance of periodontal diseases extends beyond oral health, as emerging evidence highlights their association with systemic conditions, including cardiovascular disorders and metabolic dysfunctions. In children, chronic inflammation may also influence growth, nutritional status, and overall quality of life.

Therefore, understanding the underlying mechanisms and clinical behavior of these diseases is essential for developing effective prevention and treatment strategies. Recent advancements in dental research have provided deeper insights into the microbial and immunological aspects of periodontal disease development. The role of specific pathogenic bacteria, coupled with dysregulated host immune responses, underscores the complexity of disease progression. Furthermore, genetic and epigenetic factors are increasingly recognized as determinants of individual susceptibility.

Modern pediatric dentistry emphasizes early diagnosis, risk assessment, and minimally invasive management approaches. Preventive strategies, including oral hygiene education, dietary counseling, and regular professional care, form the cornerstone of disease control. At the same time, innovative therapeutic modalities such as probiotics, laser-assisted therapy, and regenerative techniques are gaining prominence in clinical practice.

This article aims to provide a comprehensive and scientifically grounded analysis of periodontal diseases in school-aged children, focusing on their prevalence, etiological factors, pathogenesis, clinical features, and contemporary treatment approaches.

Literature Review: The scientific literature on periodontal diseases in children reflects a growing recognition of their epidemiological and clinical importance. Early studies primarily focused on gingivitis as a benign and reversible condition; however, more recent research emphasizes its potential progression to more severe periodontal pathology if left untreated. Large-scale epidemiological surveys have revealed significant variations in disease prevalence across different populations, influenced by socioeconomic status, cultural practices, and access to healthcare services.

Microbiological investigations have identified dental plaque as the primary etiological factor in periodontal disease development. The biofilm consists of a complex community of microorganisms, including Gram-negative anaerobic bacteria known for their pathogenic potential. Advances in molecular techniques have enabled the identification of specific bacterial species associated with periodontal destruction, highlighting the role of microbial dysbiosis rather than mere bacterial presence.

Immunological studies have further elucidated the host response mechanisms involved in periodontal disease progression. The interaction between bacterial antigens and host immune cells triggers the release of inflammatory mediators such as cytokines, prostaglandins, and

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matrix metalloproteinases. These mediators contribute to tissue breakdown and bone resorption, representing key elements of disease pathogenesis. Importantly, the balance between protective and destructive immune responses determines the clinical outcome.

Genetic research has identified several polymorphisms associated with increased susceptibility to periodontal diseases. These findings suggest that individual variability in immune response may explain differences in disease severity among children with similar environmental exposures. Additionally, hormonal changes during puberty have been shown to influence gingival inflammation, further complicating the clinical picture in school-aged populations.

Clinical studies have categorized periodontal diseases in children into various forms, including chronic gingivitis, aggressive periodontitis, and periodontal manifestations of systemic conditions. Aggressive periodontitis, although relatively rare, is characterized by rapid progression and significant tissue destruction, often requiring specialized management.

Preventive and therapeutic strategies discussed in the literature emphasize the importance of early intervention. Mechanical plaque removal remains the cornerstone of treatment, supported by adjunctive measures such as antimicrobial agents and professional dental cleaning.The role of patient education and behavioral modification is consistently highlighted as a critical factor in achieving long-term success.

Recent innovations in periodontal therapy include the use of probiotics to modulate oral microbiota, laser therapy for minimally invasive treatment, and regenerative techniques aimed at restoring lost periodontal structures. These approaches reflect a shift toward personalized and biologically oriented treatment paradigms.

Overall, the literature underscores the multifactorial nature of periodontal diseases in children and the necessity of integrating epidemiological, biological, and clinical perspectives in their management.

Results: Analysis of contemporary scientific studies and academic dissertations reveals that periodontal diseases in school-aged children exhibit distinct epidemiological and clinical patterns. The prevalence of gingivitis remains consistently high across diverse populations, with reported rates ranging from 65% to 85% among children aged 6 to 15 years. These findings indicate that gingival inflammation is nearly universal in this age group, primarily due to inadequate oral hygiene practices and limited awareness of preventive measures.

More severe forms of periodontal disease, including aggressive periodontitis, are less common but demonstrate significant clinical relevance. Studies report prevalence rates between 0.2% and 2%, with higher incidence observed in specific populations with genetic predisposition or systemic conditions. Despite their low frequency, these cases are characterized by rapid attachment loss and early alveolar bone destruction, underscoring the importance of early detection and intervention.

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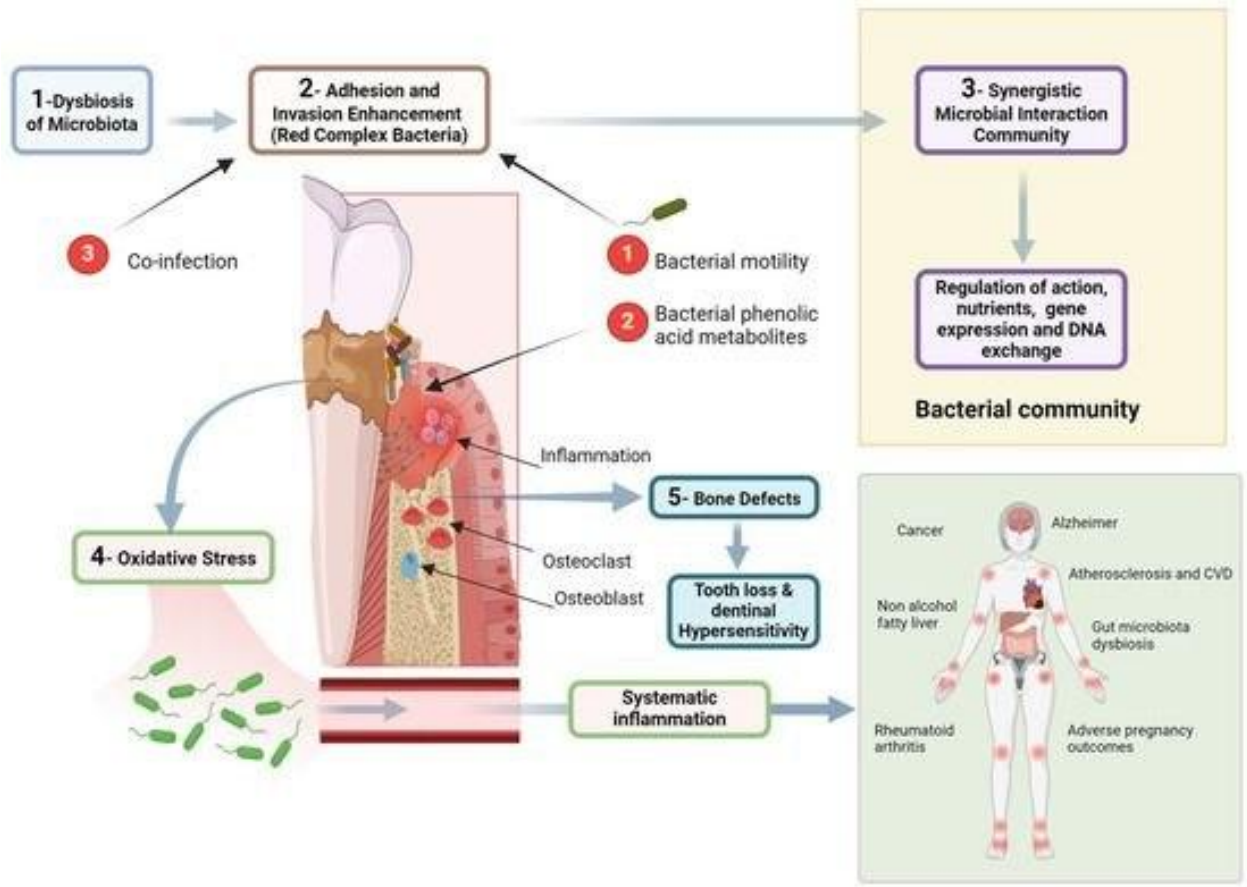

Figure 1. Figure illustrating the pathogenic mechanisms linking dysbiosis of the oral microbiota to systemic diseases. The process begins with microbial imbalance, leading to the adhesion and invasion of red complex bacteria, which enhance pathogenicity through motility and phenolic acid metabolites. A synergistic bacterial community further regulates gene expression and nutrient exchange, promoting inflammation and oxidative stress. These factors contribute to bone defects, tooth loss, and dentin hypersensitivity. Additionally, systemic inflammation resulting from periodontal disease is associated with broader health implications, including cardiovascular disease, Alzheimer's disease, rheumatoid arthritis, cancer, and adverse pregnancy outcomes. The diagram highlights the intricate relationship between oral and systemic health, emphasizing the need for periodontal disease management in preventing systemic conditions.

Etiological analysis confirms that dental plaque remains the primary causative factor, with microbial composition playing a critical role in disease progression. Research indicates a shift from a predominantly Gram-positive microbial environment in healthy individuals to a Gram-negative anaerobic profile in diseased states. This transition is associated with increased production of virulence factors, including endotoxins and enzymes that contribute to tissue destruction.

Host-related factors also significantly influence disease development. Immunological studies demonstrate that children with heightened inflammatory responses exhibit more severe periodontal destruction. Elevated levels of pro-inflammatory cytokines and reduced regulatory

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mechanisms have been observed in affected individuals. Furthermore, nutritional deficiencies, particularly in vitamins C and D, have been linked to compromised periodontal health.

Clinical observations highlight that gingivitis in children often presents with mild symptoms, including gingival redness, swelling, and bleeding on probing. However, these signs are frequently overlooked by both patients and caregivers, leading to delayed diagnosis. In contrast, aggressive periodontitis presents with more pronounced clinical features, such as tooth mobility, deep periodontal pockets, and radiographic evidence of bone loss.

Therapeutic outcomes reported in the literature emphasize the effectiveness of combined treatment approaches. Mechanical plaque control, including professional cleaning and patient education, remains the most effective intervention for gingivitis. Adjunctive use of antimicrobial agents, such as chlorhexidine, has been shown to enhance treatment outcomes. Innovative treatment modalities demonstrate promising results in managing more advanced cases. Laser therapy has been associated with reduced inflammation and improved healing, while regenerative techniques, including guided tissue regeneration, show potential in restoring periodontal structures. Additionally, the use of probiotics has been linked to improved microbial balance and reduced inflammatory response.

Preventive programs implemented in school settings have demonstrated significant reductions in disease prevalence, highlighting the importance of early education and regular dental check-ups. These findings collectively underscore the necessity of a comprehensive approach to periodontal disease management in children.

Discussion: The findings presented in this study highlight the widespread nature of periodontal diseases among school-aged children and underscore the complexity of their underlying mechanisms. The high prevalence of gingivitis reflects a combination of behavioral, environmental, and biological factors, with inadequate oral hygiene emerging as the most consistent determinant. However, the transition from gingivitis to more severe forms of periodontal disease is not solely dependent on plaque accumulation but involves a dynamic interplay between microbial activity and host immune response.

One of the key insights derived from the analysis is the role of microbial dysbiosis in disease progression. The shift toward a pathogenic microbial profile suggests that periodontal diseases should be viewed not merely as infections but as ecological imbalances within the oral cavity. This perspective has important implications for treatment strategies, emphasizing the need for approaches that restore microbial equilibrium rather than simply eliminating bacteria. The influence of host factors, including genetic predisposition and immune response variability, further complicates the clinical picture. Children with heightened inflammatory responses are more susceptible to tissue destruction, even in the presence of similar microbial challenges. This observation supports the concept of personalized medicine in pediatric dentistry, where treatment protocols are tailored to individual risk profiles.

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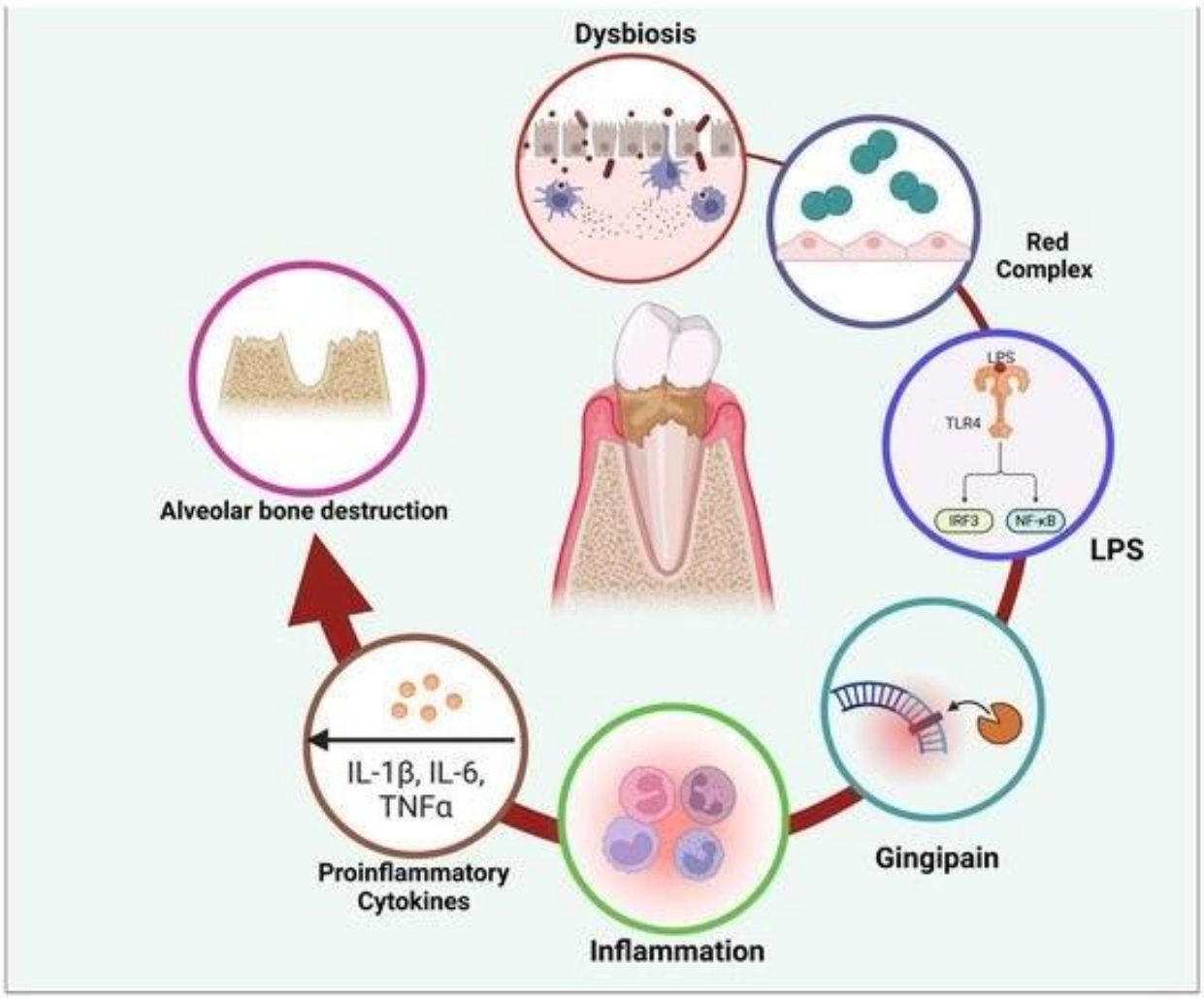

Figure 2. Figure illustrating the pathogenic cycle of periodontal disease, beginning with dysbiosis—an imbalance in the oral microbiota—leading to the dominance of red complex bacteria. These bacteria produce virulence factors such as lipopolysaccharides (LPS) and gingipains, which trigger an immune response. LPS activates Toll-like receptors (TLRs), stimulating intracellular signaling pathways (IRF3 and NF-κB) that promote the release of proinflammatory cytokines, including IL-1β, IL-6, and TNFα. This inflammatory cascade contributes to tissue damage and alveolar bone destruction, perpetuating disease progression. The cycle highlights the interplay between microbial factors and host immune responses in periodontal disease pathogenesis.

Hormonal changes during puberty represent another critical factor influencing periodontal health. Increased levels of sex hormones can enhance vascular permeability and inflammatory response in gingival tissues, leading to exaggerated clinical manifestations. This highlights the importance of targeted preventive measures during specific developmental stages.

The clinical course of periodontal diseases in children is often characterized by subtle early signs, which may progress rapidly if left untreated. This underscores the necessity of регуляр dental examinations and early diagnostic interventions. The integration of advanced diagnostic

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tools, such as biomarker analysis and digital imaging, may enhance the accuracy of early detection.

Modern treatment approaches reflect a shift toward minimally invasive and biologically oriented strategies. While traditional methods such as mechanical plaque removal remain fundamental, adjunctive therapies are increasingly utilized to improve outcomes. Laser therapy, for instance, offers advantages in terms of reduced tissue trauma and enhanced healing. Similarly, regenerative techniques represent a promising avenue for restoring periodontal structures, particularly in cases of aggressive periodontitis. Preventive strategies remain the cornerstone of periodontal disease management. Educational programs targeting children, parents, and educators play a crucial role in promoting oral hygiene practices and reducing disease prevalence. School-based interventions have demonstrated significant effectiveness, highlighting the importance of community-level approaches.

Despite significant advancements, several challenges persist in the management of periodontal diseases in children. Limited access to dental care, particularly in low-resource settings, continues to hinder effective prevention and treatment. Additionally, variability in clinical presentation and disease progression complicates the development of standardized treatment protocols.

Future research should focus on identifying reliable biomarkers for early diagnosis, exploring the role of the oral microbiome in greater detail, and developing innovative therapeutic approaches that address both microbial and host factors. Interdisciplinary collaboration between dental professionals, pediatricians, and public health specialists is essential to address the multifaceted nature of these diseases.

Overall, the discussion emphasizes that periodontal diseases in school-aged children represent a complex and dynamic health issue requiring comprehensive, evidence-based, and individualized management strategies.

Conclusion: Periodontal diseases in school-aged children constitute a significant oral health challenge with potential long-term consequences if not addressed своевременно. The high prevalence of gingivitis and the presence of more aggressive forms of periodontitis highlight the need for increased awareness, early diagnosis, and effective management strategies. The multifactorial etiology of these diseases, involving microbial, immunological, genetic, and environmental factors, underscores their complexity and the necessity of a comprehensive approach to prevention and treatment. Advances in scientific research have improved understanding of disease mechanisms, enabling the development of more targeted and minimally invasive therapeutic methods. Preventive measures, including oral hygiene education, регуляр dental check-ups, and community-based programs, remain the most effective means of reducing disease burden. At the same time, modern treatment approaches incorporating antimicrobial therapy, laser технологии, and regenerative techniques offer promising outcomes for more severe cases. Ultimately, improving periodontal health in children requires coordinated efforts at individual, clinical, and общественный levels. Early intervention and personalized care strategies are essential for ensuring optimal oral health outcomes and preventing the progression of periodontal diseases into adulthood.

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