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REVIEW

Biochemistry of periodontal diseases

Bioquímica de las periodontopatías

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ABSTRACT

Periodontal diseases are chronic inflammatory conditions with multiple causes, mainly caused by bac-teria such as Porphyromonas gingivalis and made worse by risk factors like poor oral hygiene, smok-ing, diabetes, obesity, and stress. Over time, our understanding of these diseases has evolved from old ideas to the current scientific approach, highlighting the role of biochemistry in understanding their causes. The objective of this literature review was to analyze the pathological mechanisms of periodontal diseases from a biochemical perspective in order to understand their etiology, diagnosis, and treatment. During the research process, the following methods were used: documentary analysis, systems approach, historical-logical analysis, analytical-synthetic analysis, and inductive-deductive analysis. A total of 10 international, national, and regional bibliographies were reviewed. The im-mune response triggered by bacterial plaque generates inflammatory mediators (cytokines, prosta-glandins) that cause tissue destruction and bone loss. In addition, there is a bidirectional relationship between periodontal diseases and systemic diseases (cardiovascular, diabetes), which reinforces their relevance to public health. Treatments vary according to severity: from scaling and root planing to regenerative surgery. Prevention, through proper oral hygiene, regular visits to the dentist, and a healthy lifestyle, is key. Periodontal diseases are a major public health challenge, and studying them from a biochemical perspective provides key opportunities to address them. A holistic approach, in-tegrating biology, biochemistry, and social care, will improve the diagnosis, treatment, and preven-tion of these diseases, benefiting both oral and general health.

Keywords: Biochemistry; Periodontal Diseases; Gingivitis; Periodontitis.

RESUMEN

Las enfermedades periodontales son patologías inflamatorias crónicas de origen multifactorial, cau-sadas principalmente por bacterias como Porphyromonas gingivalis y agravadas por factores de ries-go como higiene oral deficiente, tabaquismo, diabetes, obesidad y estrés. Su evolución histórica muestra un avance desde concepciones antiguas hasta el enfoque científico actual, destacando el pa-pel de la bioquímica en la comprensión de su etiología. El objetivo de la presente revisión bibliográ-fica fue analizar los mecanismos patológicos de las periodontopatías desde la perspectiva bioquímica para la comprensión de su etiología, el diagnóstico y su tratamiento. Durante el proceso de investiga-ción se utilizaron los métodos análisis documental, enfoque de sistema, análisis histórico-lógico, ana-lítico-sintético e inductivo-deductivo. Se revisaron un total de 10 bibliografías internacionales, nacio-nales y territoriales. La respuesta inmunitaria desencadenada por la placa bacteriana genera media-dores inflamatorios (citoquinas, prostaglandinas) que provocan destrucción tisular y pérdida ósea. Además, existe una relación bidireccional entre las periodontopatías y enfermedades sistémicas (car-diovasculares, diabetes), lo que refuerza su relevancia en la salud pública. Los tratamientos varían según la gravedad: desde raspado y alisado radicular hasta cirugías regenerativas. La prevención, mediante higiene oral adecuada, visitas regulares al estomatólogo y estilo de vida saludable, es cla-ve. Las periodontopatías son un reto importante para la salud pública, y su estudio desde la bioquí-mica brinda oportunidades claves para abordarlas. Un enfoque holístico, que integre la biología, la bioquímica y la atención social, permitirá mejorar el diagnóstico, tratamiento y prevención de esas enfermedades, beneficiando tanto la salud bucal como la general.

Palabras clave: Bioquímica; Periodontopatías; Gingivitis; Periodontitis.

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INTRODUCTION

Oral diseases are highly prevalent. Worldwide, 3,5 billion people suffer from them, and they are closely related to noncommunicable diseases.[1] Globally, 796 million people suffer from periodontal diseases, which are considered to be among the three most prevalent oral diseases.[2]

The economic burden imposed by poor oral health and the direct and indirect costs of oral diseases amount to US$545 billion worldwide,[3] placing them among the most costly health issues. In addition to pain, discomfort, and a reduced quality of life, oral health problems cause absenteeism from school and work,[4] which in turn leads to learning deficits and productivity losses.

Poor oral health negatively affects quality of life and healthy aging, both physically and mentally, and is highly associated with cardiovascular disease, diabetes, cancer, pneumonia, and premature births,[5] reflecting significant inequalities between countries, disproportionately affecting low- and middle-income countries, and impacting vulnerable individuals and other at-risk groups in particular.

Our understanding of periodontal disease has evolved significantly since its first descriptions in ancient times. In the distant past, tooth loss was mainly attributed to poor oral hygiene and dietary factors. However, it was in the 20th century that a more scientific approach emerged.[6]

In 1911, the concept of "periodontitis" was introduced to describe inflammation of the periodontal tissues. During this period, advances in microbiology allowed researchers to identify the role of bacteria in these conditions.[6]

In the following decades, research focused on understanding how bacterial infections could trigger immune responses, leading to the formulation of hypotheses about the etiology of periodontal diseases. From the second half of the 20th century onwards, the development of biochemical and molecular techniques allowed for a more detailed analysis of the factors contributing to the pathogenesis of these diseases.[6,7]

Six warning signs have been confirmed: bleeding when brushing; red, swollen, and tender gums; teeth that move or separate; persistent bad breath; pus between teeth and gums; and changes in bite.[6,7]

Periodontopathies, or periodontal diseases, are infections that affect the tissues surrounding and supporting the teeth, including the gums, alveolar bone, periodontal ligament, and root cementum. These diseases are of great relevance in the field of dentistry and public health, as they can lead to tooth loss and are related to a number of systemic health problems.[6,7]

There are two types of periodontal diseases: gingivitis and periodontitis. The difference between them is the degree of gum infection, which is less in cases of gingivitis and greater in periodontitis.[6,7]

In some cultures, periodontal diseases are considered a purely cosmetic problem rather than a disease. However, in today's societies, where emotional and social well-being are highly valued, good oral and periodontal health deserves to be a high priority.[1]

Although largely preventable, periodontal diseases continue to be a major public health problem in all countries around the world. Periodontal diseases from a biochemical perspective, their historical evolution, the underlying molecular biology, and their contemporary relevance to general health allowed the authors to set themselves **the objective** of analyzing the pathological mechanisms of periodontal diseases from a biochemical perspective in order to understand their etiology, diagnosis, and treatment.

METHOD

A literature review on the subject was conducted in May and June 2025, using databases such as Scopus, Scielo, Dialnet, Redalyc, LILACS, and Google Scholar. A total of 10 bibliographies published in scientific journals or documents issued by international or national institutions or organizations were reviewed, covering studies conducted at the international and national levels.

Theoretical and empirical methods were used during the research process. The main methods used were documentary analysis, a systems approach, historical-logical analysis, analytical-synthetic analysis, and inductive-deductive analysis.

DEVELOPMENT

Periodontics is the specialty within Stomatological Sciences dedicated to the study, prevention, and treatment of pathologies affecting the tissues that protect, surround, and support the teeth, gums, alveolar bone, periodontal ligament, and root cementum. Periodontal disease (PD) has traditionally been considered a chronic inflammatory disease of multifactorial origin, whose primary etiological factor is a highly organized bacterial biofilm in an ecological niche favorable to its growth and development.[6]

Combined with additional local and systemic factors, it causes infection and destruction of the tooth's supporting tissues (epithelia, connective tissue, periodontal ligament, alveolar bone, root cementum). Its main clinical manifestations include bleeding, tooth mobility, gingival recession, periodontal pocket formation, masticatory dysfunction, and tooth loss.[6]

The pathogenic process of periodontal disease is the result of the host's response to tissue destruction induced by bacteria, which is initiated by anaerobic bacteria but expanded by host cells. The body produces enzymes that destroy the supporting tissues to allow them to move away from the initial lesion.[7]

1. Gingivitis: this is the mildest form of periodontal disease and is characterized by inflammation of the gums. Common symptoms include redness, swelling, and bleeding of the gums during brushing or flossing. Gingivitis is generally reversible with good oral hygiene.[7]

2. Periodontitis: this is a more severe form of the disease that can result from untreated gingivitis. At this stage, inflammation and infection not only affect the gums but also compromise the bone that supports the teeth, which can lead to tooth loss. Periodontitis comes in several forms, varying in severity, and can include chronic periodontitis and aggressive periodontitis.[7]

The development of periodontal disease is influenced by modifiable and non-modifiable factors:

Modifiable Factors:

1. Poor oral hygiene: one of the most common causes of periodontal disease is a lack of consistent oral care. The buildup of bacterial plaque on teeth and gums can lead to inflammation and infection.
2. Tobacco: smoking is a significant risk factor for the development of periodontal disease. The chemicals in tobacco can damage gum health and hinder the healing of oral tissues.
3. Diabetes: uncontrolled diabetes can increase the risk of gum infections and affect the body's ability to fight them. In addition, periodontal disease can make it difficult to manage diabetes.
4. Stress: stress can negatively affect the immune system, which can predispose people to infections, including those affecting the gums.
5. Poor nutrition: a diet low in essential nutrients can compromise gum health. In particular, vitamin C deficiency is associated with an increased risk of periodontal disease.

Non-modifiable factors:[7]

1. Genetics: some people may be predisposed to developing periodontal disease due to hereditary factors. This means they may be more susceptible to inflammation and infections in the gums.
2. Age: the risk of developing periodontal disease increases with age, partly due to the accumulation of risk factors over time.
3. Gender: some studies suggest that men may be at greater risk for periodontal disease than women, possibly due to differences in health behaviors and hygiene habits.

Biochemical Aspects of Periodontal Diseases

Oral microbiota and bacterial composition (figure 1)

The first aspect to consider is the oral microbiota. The mouth is home to a complex community of microorganisms, which coexist in balance under healthy conditions.[8]

However, an alteration in this balance can lead to an increase in the population of pathogenic bacteria, which initiates an inflammatory process. Among the main bacteria involved in periodontal diseases are: Porphyromonas gingivalis, Tannerella forsythia, and Treponema denticola, among others.[8]

From a biochemical perspective, these bacteria produce a variety of virulence factors, such as endotoxins, which can induce an inflammatory response. The interaction of these pathogens with the human immune system is complex and involves the production of pro-inflammatory cytokines, which in turn can contribute to the destruction of periodontal tissues.[8]

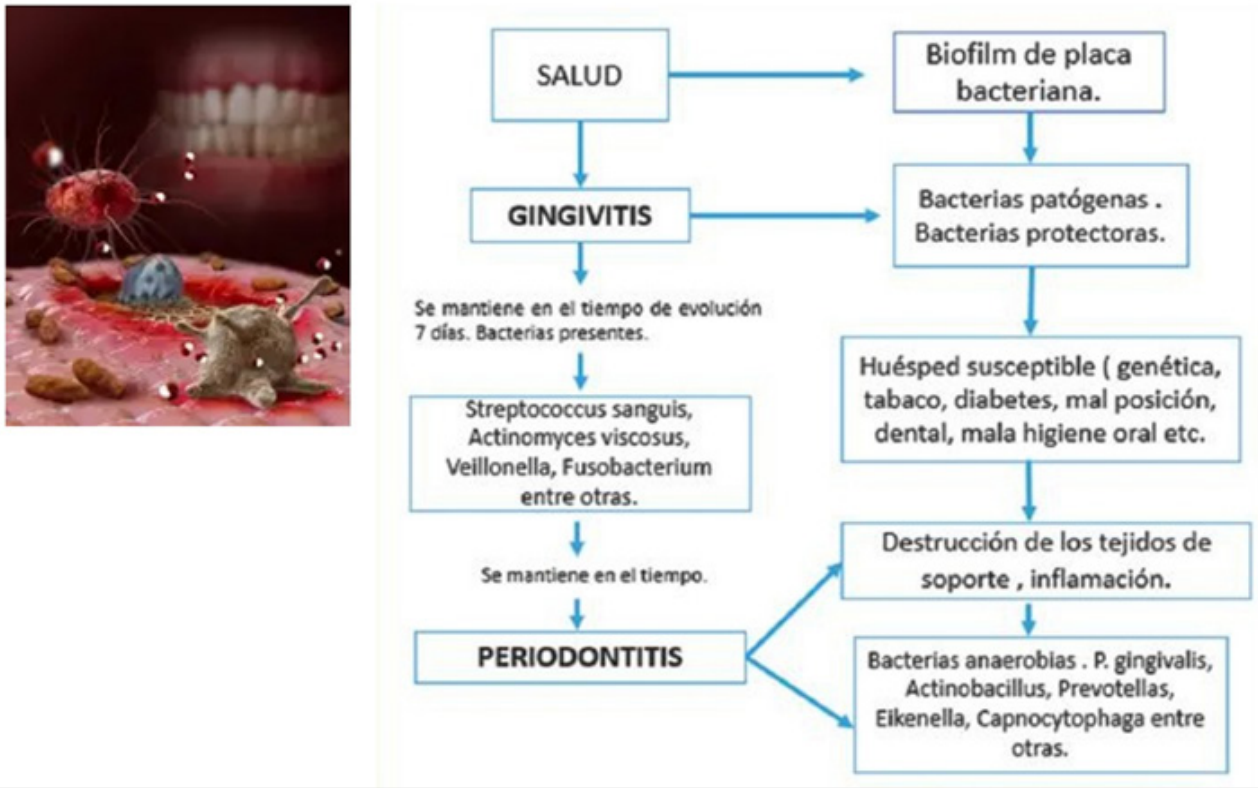

Figure 1. Oral microbiota and bacterial composition

Immune response and hormonal mediators (figure 2)

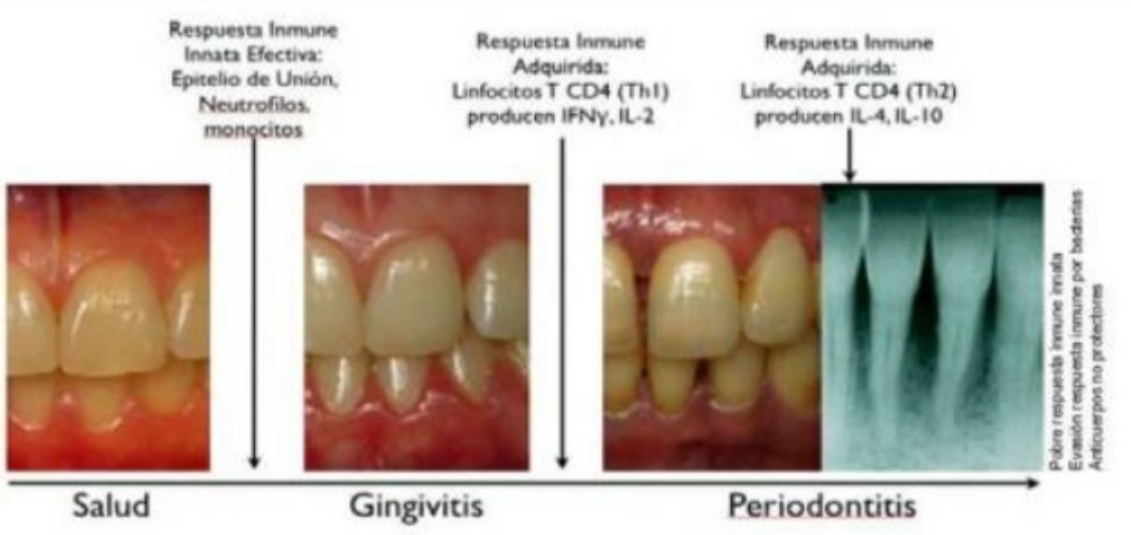

Figure 2. Immune response and hormonal mediators

The immune system's response to periodontal infection is an intriguing process. When pathogenic bacteria establish themselves in the dental biofilm, the immune system responds by activating immune cells that produce cytokines. These signaling molecules are crucial for coordinating the inflammatory response. However, in some cases, exacerbated inflammation can result in tissue damage.[8]

A fascinating biochemical aspect is the role of hormonal mediators, such as prostaglandins, which are produced in response to inflammation. Prostaglandins, particularly PGE2, are critical factors in the bone resorption that accompanies periodontal disease. The biochemistry of the prostate in relation to bone tissue regulation may be a rich line of research that will lead to a better understanding of the progression of these diseases.[8]

Hormonal mediators play an important role in women's periodontal health due to the hormonal changes they experience throughout their lives (puberty, menstrual cycle, pregnancy, and menopause). These fluctuations can affect the inflammatory response of periodontal tissues, increasing susceptibility to diseases such as gingivitis and periodontitis.[8]

Metabolic risk factors (figure 3)

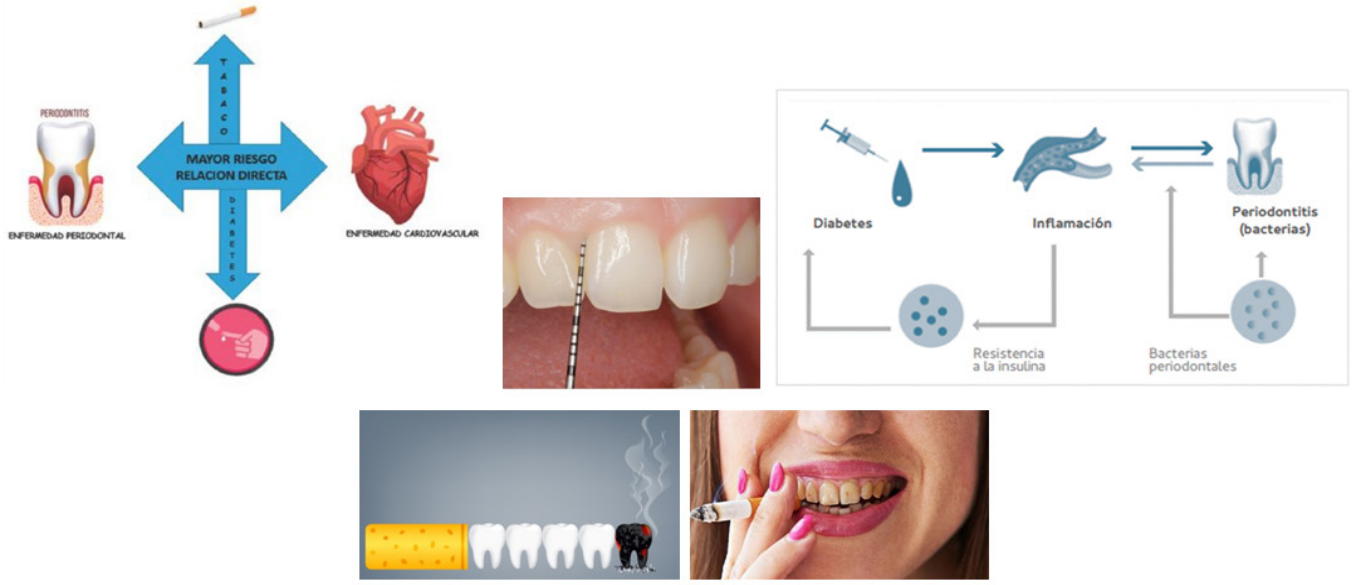

Figure 3. Metabolic risk factors

There are several risk factors associated with periodontal disease, including diabetes, smoking, and obesity. From a biochemical perspective, diabetes mellitus, for example, is associated with altered blood glucose levels that can negatively affect the immune response. This translates into increased susceptibility to periodontal infections, which has been supported by multiple studies.[8]

Smoking also introduces a number of chemical compounds into the oral cavity that affect periodontal health. Nicotine and other toxic agents in tobacco smoke can interfere with vascularization and the inflammatory response, thereby exacerbating periodontal

tissue loss.[8]

Contemporary relevance

Periodontal diseases have a significant impact on public health. According to the World Health Organization (WHO), they are one of the leading causes of tooth loss in older adults.[1,2]

In addition, a bidirectional relationship has been found between periodontal health and several systemic conditions, such as cardiovascular disease, diabetes, and respiratory disease. This highlights not only the importance of treating periodontal disease, but also of preventing it.[1,2,3,4,5]

- Implications for Systemic Health. One aspect that has gained relevance in recent years is the connection between periodontal disease and systemic conditions. Several studies have suggested that chronic inflammation caused by periodontal disease may contribute to atherosclerosis and, consequently, cardiovascular disease. Inflammation biomarkers and lipid profile modification are areas that are being rigorously examined to demonstrate this connection.[6]
- Advances in diagnosis and treatment. Advances in biochemistry have enabled the development of new diagnostic tools, such as the measurement of biomarkers in saliva that can help identify early stages of periodontal disease. In addition, laser therapy and antimicrobial treatments are revolutionizing the way these diseases are managed.[8,9]
- The management of periodontal diseases has also begun to integrate personalized medicine, where treatments are tailored to the patient's genetics and biochemical profile. This represents a significant step forward in improving the effectiveness of therapies.[8,9]

Treatments for Periodontitis

In the case of periodontitis, if it is not advanced, treatment may consist of basic therapy: scaling and root planing (SRP), less invasive procedures:[6,7,8,9,10]

- Scaling: scaling removes tartar and bacteria from the surface of the teeth and below the gums. It can be performed with instruments, a laser, or an ultrasonic device.
- Root planing: root planing smooths the root surfaces, discouraging further tartar and bacteria buildup, and removes bacterial byproducts that contribute to inflammation and delay healing or reattachment of the gum to the tooth surfaces.
- Antibiotics: topical or oral antibiotics can help control bacterial infection. Topical antibiotics may consist of antibiotic mouthwashes or gels, which are applied to the space between the teeth and gums or inside the pockets after deep cleaning. However, oral antibiotics may be necessary to completely eliminate the bacteria causing the infection. If periodontitis is advanced, treatment may require dental surgery.

Chronic periodontitis progresses more slowly, and its main symptoms are the formation of periodontal pockets and gum recession. Tartar buildup is the main cause of periodontitis, but there are some factors that can facilitate the onset of this condition, such as smoking or systemic diseases. Aggressive periodontitis is usually caused by a genetic factor.[6,8,9]

This type of disease progresses rapidly and leads to alveolar bone loss. While chronic periodontitis affects adults to a greater extent, aggressive periodontitis mainly develops in young people and adolescents between the ages of 10 and 30.[6,8,9]

Both require advanced treatments involving periodontal surgery and tissue regeneration:[6,7,8,9,10]

- Flap surgery (pocket reduction surgery): the periodontist makes small incisions in the gum to lift a section of gum tissue, exposing the roots for more effective scaling and planing. Because periodontitis causes bone loss, the hidden bone can be reshaped before the gum tissue is sutured back into place. It will then be easier to clean these areas and keep the gum tissue healthy.
- Soft tissue grafts: when gum tissue is lost, the gum line recedes. Reinforcement of some of the damaged soft tissue may be necessary. This is usually done by removing a small amount of tissue from the roof of the mouth (palate) or using tissue from another donor source and attaching it to the affected site. This can help reduce gum recession, cover exposed roots, and give the teeth a more pleasing appearance.
- Bone graft: this procedure is performed when periodontitis has destroyed the bone surrounding the tooth root. The graft may consist of small bone fragments from the patient themselves, or the bone may be synthetic or donated. Bone grafting helps prevent tooth loss by holding the tooth in place. It also serves as a platform for new natural bone growth.
- Guided tissue regeneration: this allows bone destroyed by bacteria to grow back. One technique involves the dentist placing a special piece of biocompatible fabric between the existing bone and the tooth. The material prevents unwanted tissue from entering the healing area, allowing the bone to grow back.
- Tissue-stimulating proteins: this technique involves applying a special gel to the root of the affected tooth. This gel contains the same proteins found in the enamel of developing teeth and stimulates the growth of healthy bone and tissue.
- Oral hygiene brings together a set of regular practices that a person follows to maintain and improve their oral health. These include brushing teeth, hygiene, and nutrition. Practicing these habits daily helps control the proliferation of bacteria in the mouth and the formation of tartar, which cause cavities and gum disease, such as gingivitis, which is simple inflammation, or periodontitis, which can lead to tooth loss, tooth support loss, or bleeding.

Preventive actions to combat PD

Prevention is key to avoiding the development of periodontal disease. Here are some effective actions:[1,2,3,4,5,6,7,8,9,10]

1. Proper oral hygiene: using correct toothbrushing techniques (e.g., the Bass method) at least twice a day and

flossing daily are essential to prevent the accumulation of bacterial plaque. In addition, using antibacterial mouthwashes (chlorhexidine) can help reduce the risk of infection.

2. Regular visits to the dentist: Scheduling regular dental checkups every six months allows for early detection of any problems. During these visits, professional cleanings can be performed and periodontal health can be evaluated.

3. Healthy lifestyle: maintaining a balanced diet and abstaining from tobacco use can have a positive impact on gum health. Stress management and regular physical activity are also beneficial. Control risk factors (quit smoking, control diabetes, lose weight, among others).

Counterarguments and challenges

Although there is growing consensus on the importance of biochemistry in understanding periodontal disease, there is also criticism of some of the scientific conclusions. One argument is that biochemical approaches may downplay social and environmental determinants of periodontal health. While microbiology and biochemistry are critical to building a comprehensive understanding, periodontal health is also influenced by education, culture, and access to medical care.[9]

Social and cultural barriers

In Cuba, despite having a free and universal healthcare system, there are gaps in dental services that affect the quality and accessibility of dental treatments. Some of the main limitations include:

1. Lack of basic materials and supplies such as resins, amalgams, cements, and anesthetics. Difficulty obtaining high-quality instruments. Limitations in modern equipment, such as digital X-rays, turbines, dental chairs, and others.

2. Problems with infrastructure, dental clinics with obsolete or poorly maintained equipment. Lack of maintenance in dental units and autoclaves (sterilization).

3. Limited medications, difficulty accessing antibiotics, analgesics, and anti-inflammatories specific to dental treatments.

4. Unequal access in rural areas. Greater availability in large cities than in rural areas, provinces, or remote municipalities.

5. Dependence on imports, the persistence of the US economic blockade, and internal crises make it difficult to purchase advanced dental materials and technology.

CONCLUSIONS

Periodontal diseases are a major public health challenge, and studying them from a biochemical perspective provides key opportunities to address them. It is crucial to consider not only biological aspects, but also the social and cultural factors that affect periodontal health. A holistic approach, integrating biology, biochemistry, and social care, will improve the diagnosis, treatment, and prevention of these diseases, benefiting both oral and general health.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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