Periodontal diseases

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The periodontal diseases are highly prevalent and can affect up to 90% of the worldwide population. Gingivitis, the mildest form of periodontal disease, is caused by the bacterial biofilm (dental plaque) that accumulates on teeth adjacent to the gingiva (gums). However, gingivitis does not affect the underlying supporting structures of the teeth and is reversible. Periodontitis results in loss of connective tissue and bone support and is a major cause of tooth loss in adults. In addition to pathogenic microorganisms in the biofilm, genetic and environmental factors, especially tobacco use, contribute to the cause of these diseases. Genetic, dermatological, haematological, granulomatous, immunosuppressive, and neoplastic disorders can also have periodontal manifestations. Common forms of periodontal disease have been associated with adverse pregnancy outcomes, cardiovascular disease, stroke, pulmonary disease, and diabetes, but the causal relations have not been established. Prevention and treatment are aimed at controlling the bacterial biofilm and other risk factors, arresting progressive disease, and restoring lost tooth support.

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Any inherited or acquired disorder of the tissues surrounding and supporting the teeth (periodontium) can be defined as a periodontal disease. These diseases may be of developmental, inflammatory, traumatic, neoplastic, genetic, or metabolic origin (table).[1,2] However, the term periodontal disease usually refers to the common inflammatory disorders of gingivitis and periodontitis that are caused by pathogenic microflora in the biofilm or dental plaque that forms adjacent to the teeth on a daily basis. Gingivitis, the mildest form of periodontal disease, is highly prevalent and readily reversible by simple, effective oral hygiene. Gingivitis affects 50–90% of adults worldwide, depending on its precise definition.[3]

Inflammation that extends deep into the tissues and causes loss of supporting connective tissue and alveolar bone is known as periodontitis (figure 1). Periodontitis results in the formation of soft tissue pockets or deepened crevices between the gingiva and tooth root. Severe periodontitis can result in loosening of teeth, occasional pain and discomfort, impaired mastication, and eventual tooth loss.

Although prevalence estimates differ on the basis of how the disease is defined, the prevalence, severity, and rate of disease progression clearly varies worldwide.[4,5] Periodontitis is generally more prevalent in developing countries,[6] although disease may not necessarily be extensive or severe in indigenous populations.[7] One large survey estimated that about 22% of US adults had mild disease and 13% had moderate or severe disease.[8] In the USA, periodontitis is consistently more prevalent in men than women, and in black and Mexican-Americans than white people.[8]

Cause

Oral microorganisms

The mouth, like all external surfaces of the body and the gut, has a substantial microflora living in symbiosis with a healthy host. The microflora of the mouth contains hundreds of species of aerobic and anaerobic bacteria. These organisms grow on tooth surfaces as complex, mixed, interdependent colonies in biofilms, and are attached and densely packed against the tooth in the deeper layers, with more motile forms in the superficial layers.[9] Cultural studies indicate that more than 500 distinct microbial species can be found in dental plaque.[10] However, molecular methods of 16S rDNA amplification reveal an even more diverse view of the subgingival bacterial flora and suggest that a large proportion of even this well-studied and familiar microbial environment remains uncharacterised.[11,12] As dental plaque matures to a state that is associated with periodontal disease, the number of gram-negative and anaerobic bacteria increases.[13–16] Bacterial counts above the gums (supragingival) on one tooth surface can exceed 1×10^9 bacteria. Below the gum, the number of bacteria ranges from 1×10^3 in a healthy shallow crevice to more than 1×10^8 in a periodontal pocket.[17] Tooth cleanings every 48 h can maintain the biofilm mass

Search strategy and selection criteria

The MEDLINE database was searched by use of PubMed to identify articles containing "periodontal", as well as specific periodontal diseases and associated conditions, or causal or risk factors discussed in this Seminar. As additional sources and crosschecks for the reliability of the search strategy, we reviewed comprehensive textbooks on periodontology.

Diseases caused by periodontal biofilm	Diseases with periodontal manifestations	Genetic disorders with periodontal manifestations
Gingivitis (acute/chronic): May be exacerbated by pregnancy, diabetes, puberty, contraceptives, ascorbic acid deprivation, menstruation Periodontitis (acute/chronic): Mostly occurs in adults as a slowly progressive chronic disease, but could be rapidly progressive and occur in children	Diabetes, lichen planus, pemphigoid, pemphigus, leukaemia, neutropenia, Wegener's granulomatosis, erythema multiforme, candidiasis, HIV/AIDS, psoriasis, tuberculosis, gonorrhoea, primary and recurrent herpes simplex infection, lupus erythematosus, histoplasmosis, linear IgA disease primary and metastatic carcinoma, Crohn's disease, drug-associated gingival enlargement	Familial and cyclic neutropenias; granulomatous disease; agranulocytosis; Langerhans' cell disease; glycogen storage disease; hypophosphatasia; and leucocyte adhesion deficiency, Papillon-Lefèvre, Chédiak-Higashi, Cohen, Ehlers-Danlos, Marfan's, Down's, Haim-Munk, and Kindlers syndromes

Table: Periodontal diseases

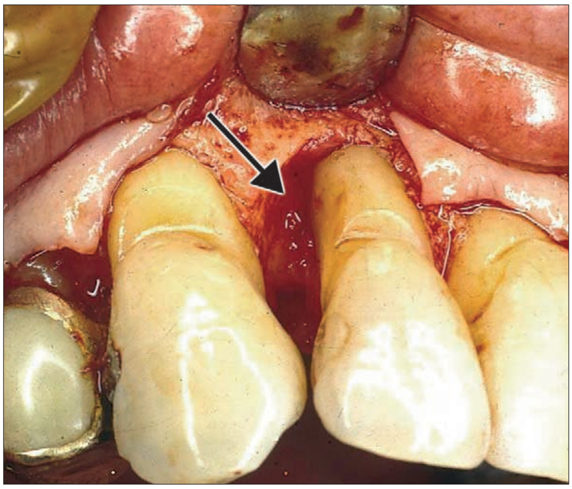

Figure 1: **Surgical exposure of bone loss (arrow) resulting from periodontitis adjacent to a maxillary anterior tooth**

at an amount compatible with gingival health.[18] Unfortunately, few individuals achieve this, and exhortations to the public to clean teeth more thoroughly are generally ineffective in public-health care.[19]

An enormous research effort has been devoted to the study of periodontal-disease-associated microflora, from classic cultural methods to modern approaches on the molecular, whole genomic, and proteomic level.[20,21] Certain clusters of bacterial species commonly cohabit subgingival sites and are reproducibly associated with disease.[22] These putative pathogens include *Porphyromonas gingivalis*, *Tannerella forsythensis*, and the spirochaete *Treponema denticola*. Infection of periodontal tissues with these and other organisms is accompanied by the release of bacterial leucotoxins, collagenases, fibrinolysins, and other proteases.[23] *Actinobacillus actinomycetemcomitans* is another species commonly associated with disease, especially in young adults.[24,25] Recent work implicates herpes viruses in the pathogenesis of periodontitis[26–28] and *Candida albicans* and other fungi in immunocompromised individuals.[29] Clearly, a variety of microorganisms can contribute differently in populations and individuals in the pathogenesis of periodontal disease.[30] In addition to the widely accepted causal factor of pathogenic microflora in the periodontal biofilm, several genetic and environmental effects on the periodontal diseases have been identified.[31]

Genetics

Rare syndromes affecting phagocytes, the structure of the epithelia, connective tissue, or teeth, could have severe periodontal manifestations. For some disorders, the responsible gene or tissue defect has been identified. Haim-Munk and Papillon-Lefèvre syndromes are rare autosomal recessive disorders associated with periodontitis onset at childhood and early loss of both deciduous and permanent teeth. These syndromes are caused by mutations in the cathepsin C gene.[32–34] Prepubertal periodontitis in some families could represent partly penetrant Papillon-Lefèvre syndrome.[35] Other disorders that have severe periodontal manifestations include Chédiak-Higashi, Ehlers-Danlos (types 4 and 8), Kindlers, and Cohen syndromes.

Data from twin studies indicate that about half the population variance in periodontitis can be attributed to genetic factors.[36–39] Moreover, accumulating evidence shows that genetic variations in or near cytokine genes could affect the systemic inflammatory response in people with periodontitis.[40,41] Although several genetic polymorphisms have been associated with periodontal disease, not enough evidence at present supports the widespread use of genetic tests to either assess risk for disease or predict treatment response.[42,43]

Tobacco and alcohol use

Smokers are much more likely than non-smokers to develop periodontitis.[44] Moreover, oral smokeless tobacco can lead to gingivitis, loss of tooth support, and precancerous gingival leucoplakia at the site of quid placement.[45–48] The risk of periodontal disease in long-term smokers is equal to that of lung cancer, and smoking has a strong negative effect in response to periodontal treatment and other oral surgical interventions.[44] In the USA, about half the risk of periodontitis can be attributable to smoking.[49,50] By contrast with tobacco use, a small but significant association exists between alcohol consumption and loss of periodontal support.[51]

HIV and AIDS

Although HIV disease has a relatively minor effect on the progression of chronic periodontitis compared with other pathogenic factors,[52] patients who are HIV-positive and immunosuppressed can present with distinctive forms of necrotising gingivitis and periodontitis.[53] Acute necrotising ulcerative gingivitis was formerly known as trench mouth, because of its high prevalence in the trenches of World War I, when stress, fatigue, malnutrition, and poor hygiene often came together to cause the disease. The disorder is characterised by pain, bleeding gums, halitosis, low-grade fever, malaise, and cervical lymphadenopathy. Nowadays, a few HIV/AIDS patients develop acute necrotising ulcerative gingivitis and its more severe counterparts, necrotising ulcerative periodontitis and necrotising mucositis. Although most HIV-positive individuals do not have these periodontal problems, the presence of necrotising ulcerative periodontitis seems to be a strong indicator of a CD4+ cell count less than 200 cells per μL.[54] With the advent of highly active antiretroviral therapies (HAART), the severity of oral symptoms of HIV has generally reduced in populations with access to HAART.[55,56] However, oral manifestations continue to be more prevalent in individuals with HIV/AIDS in sub-Saharan Africa[57,58] than in other regions or countries.[59,60]

Nutrition
Historically, specific, overt nutritional deficiencies have been associated with periodontal disease. Vitamin C deficiency leads to scurvy with decreased formation and maintenence of collagen, increased periodontal inflammation, haemorrhage, and tooth loss. However, extensive epidemiological studies in Europe and the USA have failed to show an effect of minor hypovitaminoses on periodontal disease. In impoverished societies, the effect of deficiencies in vitamins, trace elements, and protein-calories is important, but poorly quantified. For example, noma (cancrum oris) is common in parts of sub-Saharan Africa. This devastating necrosis of oral and facial soft tissues, which usually starts as acute necrotising ulcerative gingivitis, is more common in individuals who are malnourished (especially kwashiorkor), who are immunosuppressed after an acute viral disease (commonly measles), or perhaps who have acquired unusual species of oral bacteria from living near cattle.[61]

Osteoporosis
Emerging evidence indicates that osteoporosis raises an individual's susceptibility to periodontal breakdown. A 3-year longitudinal study of 179 Japanese people older than 70 years showed significantly increased progression of periodontal attachment loss in patients with osteopenia.[62] NHANES III data from more than 5900 US women indicated that, in the presence of high dental calculus scores, women with osteoporosis are at increased risk for periodontal attachment loss, and that this risk could be attenuated by oestrogen replacement therapy.[63]

Diabetes
Results from cross-sectional and prospective cohort studies are strikingly consistent; people with type 1 diabetes at all ages and adults with type 2 diabetes have more widespread or severe periodontal disease than individuals without diabetes.[64,65] Although people with well-controlled diabetes do not seem to be at increased risk of periodontal disease than people without diabetes, those with poorly controlled diabetes (who are at risk for retinopathy, nephropathy, neuropathy, and macrovascular diseases) are at raised risk for periodontitis and progressive bone loss.[64,66,67]

In light of the macroscopic and microscopic sequelae of diabetes, the fact that individuals with diabetes of both types are at raised risk for periodontitis is not unexpected. Diabetes is associated with impaired wound healing, exaggerated monocyte response to dental plaque antigens,[68] and impaired neutrophil chemotactic responses,[69] all of which can lead to increased local tissue destruction. With the possible exception of *P gingivalis*, the bacterial composition of subgingival periodontal biofilm does not seem to differ substantially between individuals with and without diabetes.[70]

Stress
As with many diseases, emotional and psychosocial stress clearly are factors in periodontal disease, but their precise role in the pathogenesis of this disease is unknown.[71,72] For example, traumatic life events that lead to depression or an individual's inability to cope with stressful stimuli could increase his or her risk for periodontal disease.[73,74]

Impaired host response
As an inflammatory disease, severe periodontal disease and loss of tooth-supporting tissues often occurs if the individual's host response or immune function is impaired. Various systemic diseases such as leukaemia, thrombocytopenia, and leucocyte disorders such as agranulocytosis, cyclic neutropenia, and leucocyte adhesion deficiency could be associated with increased severity of periodontal disease.

Pathogenesis
Although bacteria are necessary for periodontal disease to take place, a susceptible host is also needed. The immune-inflammatory response that develops in the gingival and periodontal tissues in response to the chronic presence of plaque bacteria results in destruction of structural components of the periodontium leading, ultimately, to clinical signs of periodontitis. An individual's risk for periodontal disease could be linked to gingival inflammation (bleeding) in response to plaque accumulation.[75–80] The host response is essentially protective, but both hyporesponsiveness and hyper-responsiveness of certain pathways can result in enhanced tissue destruction.[81]

Both the host and bacteria in the periodontal biofilm release proteolytic enzymes that damage tissue. They release chemotactic factors that recruit polymorphonuclear leucocytes into the tissues; if sustained, these cells release various enzymes that break down tissues. Hundreds or even thousands of microbial antigens evoke both humoral antibody-mediated and cell-mediated immune responses. These responses are usually protective, but a sustained microbial challenge in the presence of the forementioned risk factors results in the breakdown of both soft and hard tissues, mediated by cytokine and prostanoid cascades. Histologically, non-progressive inflammatory foci tend to be composed predominantly of T lymphocytes and macrophages, suggesting that the cell-mediated response can control disease.[82] Destructive lesions are dominated by B lymphocytes and plasma cells, suggesting that humoral immunity is not always effective.

Once a periodontal pocket forms and becomes filled with bacteria, the situation becomes largely irreversible. Gingival epithelium proliferates to line the pocket and

Figure 2: Radiograph of maxillary central incisor with periodontitis showing loss of bone support

even if treatment resolves the inflammation and some bone and connective tissue are regenerated, complete restoration of the lost tooth support is impossible. Without adequate treatment, active periodontitis leads to tooth loss.

Diagnosis

Clinical findings of chronic gingivitis and periodontitis

Chronic gingivitis often results in mild bleeding from the gums during tooth brushing, which is generally only a minor inconvenience unless underlying blood dyscrasias or bleeding disorders exist. Chronic periodontitis is usually asymptomatic until the disease is so severe that teeth shift, loosen, or are lost. Individuals with advanced periodontitis may also have recurrent periodontal abscesses and halitosis.

The clinical diagnosis of chronic periodontal disease is based on visual and radiographic assessment (figure 2) of the periodontal tissues and on measurements of the space between the tooth and gum.[83] These spaces are normally 1–3 mm in depth, and deepen as supporting connective tissue and bone are lost.[84] During a comprehensive clinical examination, pocket depths and tissue support are measured at four to six locations around every tooth and the amount of supragingival periodontal biofilm (plaque), dental calculus, gingival bleeding, and exudate are recorded.[83] These procedures are needed to diagnose existing disease, determine the prognosis of individual teeth, and monitor disease progression that tends to be episodic and specific to the tooth and site.[85] In epidemiological surveys, measurements are obtained from fewer sites in the dentition. Although useful for estimating disease severity,[86] partial examination protocols could greatly underestimate disease prevalence.[87]

Dental radiographs are routinely used to assess the amount of bone support for the teeth and identify other pathological conditions. Compared with conventional radiography, the use of digital subtraction radiography can enhance the ability to detect periodontal bone loss over time,[88–90] but is restricted by the need for standardised geometric images.[91]

Microbial assessment of periodontal biofilm

Although diagnoses and treatment decisions are sometimes helpful to guide antibiotic therapy for a few patients, they are not usually based on microbiological findings. There is insufficient evidence that microbial assessment can improve treatment outcomes for common forms of chronic periodontitis, and there is only limited evidence that such assessment can improve outcomes for refractory or aggressive forms of periodontal disease.[92]

Emerging diagnostic methods

The inflammatory exudate adjacent to the teeth contains several biomarkers of periodontal inflammation that might be useful in the prediction of future disease risk (prostaglandin E_2, cathepsin B, neutrophil elastase, collagenase, β glucuronidase, aspartate aminotransferase, arylsulphatase, non-specific neutral proteinase). Commercial assays are available for some of these biomarkers,[93] but they are not used widely in clinical practice because of uncertainties about their predictive value and the added time and cost needed.

Intraoral CT is used in various oral and craniofacial applications including placement of dental implants. Future advances could provide practitioners with three-dimensional views of the alveolar bone and the ability to detect subtle changes in bone height and density over time.[91,94] The area of salivary diagnostics is in its infancy and, one day, saliva could replace blood as the fluid of choice for medical laboratory assessment. For example, saliva has been used to non-invasively monitor viral loads and systemic drug concentrations,[95] to measure C-reactive protein as a risk marker for cardiovascular disease by use of a laboratory microchip,[96] and possibly to detect oral cancer.[97,98] Saliva-based diagnostic methods for periodontal diagnosis are promising because periodontal pathogens[99] and host antibacterial proteins[100] are readily detectable in saliva, but their usefulness in periodontal diagnosis and treatment remains undetermined.

Periodontal manifestatons of systemic diseases

Various systemic diseases could be manifest in the periodontal tissues.[2] These disorders include herpetic

Figure 3: **Myelogenous leukaemia with neoplastic cellular infiltration of the gingiva and ecchymosis**

Figure 5: **Fibrous gingival enlargement associated with phenytoin treatment for a seizure disorder**

and other viral infections; dermatological conditions such as lichen planus, pemphigoid, and pemphigus; haematological diseases such as leukaemia and neutropenia (figure 3); granulomatous diseases such as tuberculosis and Wegener's granulomatosis (figure 4); and primary and metastatic carcinoma. Diagnosis of these atypical forms of disease is based on clinical as well as pertinent laboratory and biopsy findings.

Gingival enlargement could be associated with various substances including phenytoin, calcium-channel-blocking drugs, and ciclosporin A, an immunosuppressant (figure 5).[101,102] In general, the enlargement begins 1–3 months after the start of drug treatment and is common in children[102] and in patients with poor oral hygiene[102,103] or gingivitis.[104] Occasionally, the enlargement can be disfiguring, interfere with mastication, and prevent healthy tooth eruption. The prevalence varies widely, depending on the drug used (phenytoin, 50%, ciclosporin, 25–70%, nifedipine, 6–15%, diltiazem, 5–20%, verapamil, <5%).[102] Although the occurrence and severity of gingival enlargement associated with these drugs can be kept to a minimum by frequent professional prophylaxes and good daily oral hygiene,[105,106] the most effective remedy is to either discontinue the drug or manage the patient's underlying disorder with another drug or another class of drugs. The effects of these substances on the gingiva are reversible in most patients once they are discontinued.[101]

Figure 4: **Wegener's granulomatosis with necrotising vasculitis and granulomatous infiltration of gingiva**

Treatment of early to moderate gingival enlargement typically includes frequent tooth cleanings and efforts to improve plaque control. If drug substitution or withdrawal is not an option, the enlarged tissues can be surgically excised, although about 35% of such patients experience recurrent lesions in 18 months.[107] Young patients and those with poor oral hygiene or who receive infrequent professional prophylaxes are at high risk for recurrent, severe gingival enlargement.[107] Health-care providers, by working to motivate patients to improve their oral hygiene and by providing frequent preventive care, can have an important role in preventing recurrence after the surgical removal of enlarged tissue.[107]

Associations with systemic diseases and conditions

Preterm birth

Several case-control or prospective cohort studies have reported a link between poor maternal periodontal health and risk for preterm birth, low birthweight, and pre-eclampsia.[108–112] Although two large studies in the UK did not find such associations,[113,114] it is important to note that studies reporting a positive association of adverse pregnancy outcomes and maternal periodontal disease included predominantly African-Americans or Hispanic-Americans who were at higher risk for these adverse outcomes than other ethnic groups.

The role of bacterial infections in preterm birth is well known; bacterial vaginosis and chorioamnionitis can lead to spontaneous preterm birth, especially in early gestation.[115] The putative link between periodontal disease and preterm birth might be attributable to repeated exposures of the decidual tissues to periodontal pathogens through bacteraemia, or to the action of inflammatory mediators produced in the periodontal tissues that could enter the systemic circulation and trigger an inflammatory cascade in the uterus.[116] Supporting evidence comes from animals, in which intravenous injection of periodontal bacteria into pregnant mice leads to premature delivery and stillbirths.[117] Oral microorganisms, including *Fusobacterium nucleatum* and *Capnocytophaga sputigena*, have been detected in the amniotic fluid of women with intact membranes[118] and those having preterm labour.[119] However, no direct evidence currently shows that these microorganisms cause preterm birth. Although severe periodontitis has been associated with increased risk for spontaneous preterm birth, it is not associated with histological chorioamnionitis, positive placental cultures, or markers of upper genital-tract inflammation.[120]

Effects of periodontal treatment

In a non-randomised study, women who received a dental cleaning during pregnancy tended to have non-significantly fewer adverse pregnancy outcomes (ie, preterm delivery <37 weeks, birthweight <2500 g) than non-treated women (13·5% *vs* 18·9%).[121] A larger randomised study in Chile showed that women who received periodontal treatment had significantly fewer preterm births or low birthweight babies than those who received the same treatment after delivery (1·84% *vs* 10·1%, p=0·001).[122] Finally, in a randomised pilot study, pregnant women who received placebo treatment plus scaling and root planing (the mechanical removal of dental plaque and calculus from the teeth with various manual or powered instruments) had fewer preterm (<35 weeks) births (0·8%) than women who received placebo treatment and simple cleanings (4·9%) or scaling and root planing plus metronidazole for 1 week (3·3%).[123] However, none of these differences was significant. Currently, two multicentre intervention trials funded by the National Institute of Dental Craniofacial Research (NIDCR) are underway in the USA to determine whether periodontal therapy can reduce the incidence of preterm birth.

Cardiovascular disease and stroke

Inflammation has been implicated in the cause and pathogenesis of atherosclerosis,[124] and periodontal inflammation could have a role in the initiation or progression of coronary artery disease and stroke. Periodontitis is associated with raised systemic concentrations of C-reactive protein, fibrinogen, and cytokines, all of which have been causally linked to atherosclerosis-induced disease.[125] Standard non-surgical periodontal treatment to reduce periodontal inflammation has been shown to reduce serum inflammatory markers and C-reactive protein.[126–129] Data from in-vitro and animal studies suggest that periodontal bacteria can both promote platelet aggregation[130] and induce the formation of foam cells.[131]

Conflicting evidence shows whether these pathogens invade vascular endothelium; some researchers have found periodontal pathogens in carotid endarterectomy samples[132,133] and in the occluded arteries of patients with Buerger's disease (thromboangiitis obliterans),[134] whereas others have not.[135] In a study of more than 6000 adults, severe periodontitis was associated with increased intima media thickening (odds ratio 1·31, 95% CI 1·03–1·66) after adjustment for common cardiovascular risk factors.[136] Moreover, several independent studies with several thousand participants have reported that systemic antibody response to several periodontal organisms was associated with coronary heart disease,[137–139] stroke,[140] and increased intima media thickening.[141] Another independent study of 1056 elderly people showed that the presence of pathogenic bacteria in the periodontal biofilm was associated with increased thickness of the carotid artery wall as measured by high-resolution B-mode ultrasonography.[142] Notably, the association was recorded in both smokers and non-smokers. In a follow-up study of the same population group, researchers reported that radiographic evidence of severe periodontal bone loss was associated with a nearly four-fold increase in risk for the presence of carotid artery plaque that can lead to stroke.[143]

Several case-control and cohort studies have reported a positive association between common inflammatory periodontal disease and risk of cardiovascular disease,[144–146] but others have failed to detect such a link.[147] Some studies have questioned this relation, because of the possible common effect of cigarette smoking on both diseases.[148] A meta-analysis of nine cohort studies concluded that periodontal disease was associated with a 19% increase in risk of future cardiovascular disease in all age groups and a 44% increase in risk in people aged 65 years or less.[149] Findings from a 12-year study of 41 380 men suggested that periodontal disease and fewer teeth could be associated with about a 1·6 times raised risk of ischaemic stroke.[150] Although the increased risk of cardiovascular disease associated with periodontal disease seems to be modest (about 20%), even this modest increase could have a profound public-health effect with respect to cardiovascular disease and stroke, since periodontal disease is so common in the population.[149] It is important to note that people who have had complete, definitive, and long-term elimination of all potential dental infections because of extraction of all teeth do not have reduced risk of coronary heart disease compared with people with diagnosed periodontitis.[151] Therefore, serial tooth extraction does not seem to reduce the risk for cardiovascular disease.

Diabetes

The relation between periodontal health and diabetes has been described as bidirectional;[64] although periodontitis is a potential complication of diabetes, emerging evidence suggests that treatment of periodontal infections in diabetics could improve glycaemic control. Common inflammatory periodontal disease also could be an independent predictor of ischaemic heart disease and death from myocardial infarction in individuals with diabetes. In a prospective study of adult Pima Indians with type 2 diabetes, age-adjusted and sex-adjusted death rates for all natural causes (per 1000 person-years of follow-up) were 3·7 (95% CI 0·7–6·6) for no or mild periodontal disease, 19·6 (0·7–28·5) for moderate periodontal disease, and 28·4 (22·3–34·6) for severe periodontal disease.[152] Periodontal disease was a significant predictor of deaths from ischaemic heart disease and diabetic nephropathy, but not from other causes. These findings and other data[153] imply that prospective cohort or intervention studies of diabetes should include periodontal disease status as an important covariate for outcomes such as death or disability. Evidence from small, randomised controlled trials suggests that treatment of periodontal disease could reduce glycated haemoglobin amounts.[154–157] Others, however, have shown no such effect.[158]

Pulmonary disease

Various respiratory infections may be associated with periodontal disease,[159,160] and there are reports that potential respiratory pathogens that cause pneumonia colonise the mouths of high-risk patients in intensive-care units.[161,162] Moreover, preliminary studies indicate that oral hygiene with either mechanical or antiseptic rinses can reduce the rate of respiratory infections in patients living in institutions.[163–165]

Prevention and treatment of chronic gingivitis and periodontitis

Prevention of gingivitis and periodontitis is based on the control of their causal and risk factors (as defined by an attribute that is causally related its pathogenesis). The most widely accepted risk factor is the periodontal biofilm that forms on the teeth in the absence of effective oral hygiene. However, various factors such as smoking, diabetes, ethnic origin, specific types of gram-negative anaerobic bacteria in the periodontal biofilm, poor education, infrequent dental attendance, genetic effects, increased age, male sex, diabetes, psychosocial stress, and depression have also been shown to be associated with loss of periodontal support, and are important considerations in the prevention and treatment of periodontitis.[71,106]

After all oral hygiene procedures (such as tooth brushing) are ceased, the biofilm begins to develop on the teeth within 24 h and causes gingivitis in 10–21 days.[166] Thorough tooth cleaning returns the gingiva to a healthy condition in about 1 week.[166] Control of the periodontal biofilm with professionally administered oral hygiene can slow or stop periodontitis and tooth loss for many years.[167]

Although community-based or school-based health education or promotion programmes are effective at reducing dental plaque and gingivitis for up to 6 months, neither the long-term effectiveness of such approaches nor their effect on tooth loss or quality-of-life outcomes have been established.[19] In many developing countries, poor general health with compromised host defences, restricted access to dental care, and inadequate oral hygiene usually translates into a high occurrence of gingivitis and periodontitis. In these high-risk areas, population-based prevention programmes aimed at self-care education and health promotion should be cost effective.[3] In this regard, WHO recently issued a policy framework for oral-health promotion that addresses environmental, economical, social, and behavioural causes of disease.[168]

Toothbrushing and the use of dental floss and other devices to remove bacterial plaque from the teeth are the most common ways of disrupting or removing the periodontal biofilm from teeth. Although these methods are effective if used every day, they require motivation and dexterity. Mouthwashes and dentifrices containing antibacterial drugs have been used as adjuncts for controlling the biofilm. These combinations contain various biocides, surfactants, polymers, or other components that can reduce the biofilm and are generally not associated with the emergence of a resistant microbiota.[169] If mouthwashes and dentifrices are used as adjuncts to mechanical cleaning methods, they can reduce gingivitis,[170,171] although their role in treating or preventing periodontitis has not been established. However, such substances could be promising treatments in the future, in view of the preliminary evidence showing that daily home use of antimicrobial compounds over an extended time could be beneficial with respect to reducing recurrence of periodontal disease after non-surgical periodontal treatment.[172]

Tobacco use is a major risk factor for periodontal disease.[46,173] Moreover, the rate of periodontal disease progression is increased in smokers and decreases to the same as non-smokers after tobacco cessation.[173] These data, coupled with evidence that smokers have a diminished response to treatment for periodontal disease,[174–180] underscores the importance of the inclusion of tobacco cessation in any prevention or treatment programme for periodontal disease.

Treatment for gingivitis and periodontitis should establish periodontal health, arrest the progression of disease, prevent recurrence of disease, and preserve the dentition in a state of health, comfort, and function. This goal can be accomplished by various non-surgical and surgical therapies, depending on the specific treatment objective.

Professional treatment of periodontitis

The cornerstone of periodontal therapy is anti-infective non-surgical treatment aimed at controlling the biofilm and other prominent risk factors. Dental plaque and calculus can be removed from tooth-crown and root surfaces (scaling and root planing) by use of various manual or powered instruments. Special attention is devoted to biofilm debridement in periodontal pockets. This non-surgical therapy, combined with improved personal oral hygiene, can reduce tissue inflammation and pocket depths and improve clinical periodontal attachment.[181–184] Supplemental use of local antibiotics, local antiseptic drugs, systemic antibiotics, and systemic use of sub-antimicrobial low-dose doxycycline have been shown to provide some additional benefit compared with debridement alone.[185–188] However, this additional benefit is clinically small compared with the effects of local mechanical therapy alone. Antibiotics are used in conjunction with scaling and root planing, but only in patients with refractory disease or in those who have fever and lymphadenopathy. Correction or replacement of defective prostheses and dental restorations that retain dental plaque is also an important part of periodontal therapy.

The patient's healing response is usually assessed in a month or two after non-surgical treatment. For patients with early or moderate disease, non-surgical treatment is often sufficient. For patients with advanced disease, a variety of types of periodontal surgery are used to reduce the depth of periodontal pockets, gain access for debridement of residual dental calculus and plaque, and stimulate regeneration of lost periodontal support by use of various surgical procedures, grafting materials, and biological substances.

Follow-up care

Successful treatment of periodontal disease is dependent on regular maintenance or supportive follow-up therapy after active treatment is completed,[189,190] especially for those with inadequate home care.[191] Such treatment should be tailored to individual patients and generally consists of mechanical debridement, reinforcement of oral hygiene, and continued efforts to control or eliminate causal and risk factors.[191] For patients with aggressive or refractory disease, re-treatment with the adjunctive use of antibiotics dictated by appropriate microbial culture and sensitivity testing might be needed.[192]

Systemic antibiotics in the treatment of periodontal disease

A wide variety of systemic antibiotics in varying doses has been used to treat periodontal disease either alone or in combination with standard non-surgical and surgical periodontal therapy.[193] Limited data exist regarding the effect of antibiotic use alone in treating periodontitis,[194–196] and the use of systemic antibiotics for the treatment of periodontal disease has a risk of adverse drug reaction and increased selection of multiple antibiotic-resistant organisms. Systemic antibiotics should only be used in conjunction with mechanical debridement and can provide the greatest benefit to patients who do not respond to debridement alone or who have fever or lymphadenopathy.[197]

Research needs

There are many needs for additional research in periodontology, including the development of biomarkers of current and future disease activity. Effective community-based and population-based means of prevention need to be investigated, and although current treatments are generally quite effective in arresting disease progression and restoring some degree of lost periodontal support, further study is needed to develop and test innovative treatment strategies that are less invasive, more cost effective and take advantage of our increasing understanding of tissue regeneration and repair on the molecular level. As observational studies report associations of common inflammatory periodontal disease with various systemic diseases, large, multicentre randomised controlled trials should be undertaken to investigate the effect of periodontal treatment on risk of systemic diseases and disorders, such as adverse pregnancy outcomes, cardiovascular disease and stroke, diabetes, and pulmonary disease.

Conflict of interest statement

We declare that we have no conflict of interest.

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