Pathogenesis of periodontitis

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Abstract. Periodontitis is an inflammatory disease of the periodontium which is characterized by a progressive destruction of the tissues supporting the tooth. Its primary etiology is an ill-defined series of microbial infections which may be composed of only some of the more than 300 species of bacteria currently recognized in the oral cavity. The disease is currently considered to progress as periodic, relatively short episodes of rapid tissue destruction followed by some repair, and prolonged intervening periods of disease remission. Despite the apparent random distribution of episodes of disease activity, the resulting tissue breakdown exhibits a symmetrical pattern of alveolar bone loss and pocket formation which is common to several forms of periodontitis, although the distribution of the most affected teeth and surfaces may vary among diseases (e. g., juvenile periodontitis versus adult periodontitis or rapidly progressive periodontitis). Several reports have indicated that bacterial cells can be found in the pocket wall of periodontitis lesions. The translocation of bacteria into the tissues from the pocket environment is quite common, as evidenced by the common occurrence of bacteremias in patients with periodontitis following relatively minor events such as chewing and oral hygiene procedures. However, it is important to distinguish between the passive introduction of bacteria into periodontal tissues and frank invasion as might occur in an acute infection, since the pathological implications may be quite different.

Key words: Inflammation – atrophy – disease activity – bacterial invasion.

Periodontitis is an inflammatory disease of the periodontal tissues which is characterized by loss of support of the affected teeth, specifically periodontal ligament fibers and the bone into which they are inserted. Periodontitis may begin as a gingivitis which spreads to the underlying tissues. However, gingivitis lesions do not necessarily progress to periodontitis.

Clinically, periodontitis lesions may be associated with varying degrees of gingival redness and swelling. In cases of long-standing disease, the gingiva may appear clinically normal with minimal swelling and redness. The gingival surface may have a firm consistency and be stippled. However, periodontal tissue damage may affect the deeper tissues, leading to progressive loss of the alveolar bone and periodontal ligament. Ultimately, the destruction of these supporting tissues results in the loss of teeth, and accounts for the major cause of tooth loss in adults (Belting et al. 1953, Marshall-Day et al. 1955, Page & Schroeder 1982).

Periodontitis is most readily detected by periodontal probing and radiographically. Visual inspection for gingival changes, while suggestive, may be misleading since periodontitis is not always accompanied by readily detectable gingival changes, while gingivitis is frequently noted in the absence of periodontitis (Marshall-Day et al. 1955, Page & Schroeder 1982, Greene 1960).

Currently, the primary cause of periodontitis is considered to be bacterial infections of long standing, the composition of which may vary from individual to individual and to a lesser extent from site to site on different teeth of the same subject. Although over 300 species of bacteria are currently recognized in the oral cavity, only 5% of these are considered to be strongly associated with periodontitis, with 1% present in over 90% of all cases of periodontitis (Slots, personal communication). Unfortunately, the complexity of the flora, the intermittent nature of episodes of disease activity, and the relative large variances in the data obtained within and between subjects have combined to hamper the identification of the causative agents of the disease in humans. Problems in experimental design and data management have also contributed to delays in the identification of the microbial etiologic agents of periodontitis.

For the purpose of this conference the pathogenesis of periodontitis will be reviewed to emphasize those aspects of periodontitis that may be relevant to the design of clinical trials and the devising of strategies to collect and analyze appropriate data. It is valuable in this context to review the changes that have taken place in the last decade in the classification of periodontitis and our understanding of the disease.

Classification

Classically, periodontitis has been subdivided into a number of categories based on what was perceived to be the main etiology of the disease in each case. The main etiologic factors are frequently divided into ill-defined *systemic* factors and more readily detectable *local* factors. The latter include mineralized and non-mineralized microbial deposits (i. e., calculus and dental plaque) on the root surfaces, occlusal trauma and "degenerative changes" in the tissues.

The following is a representative listing of the main categories of periodontitis, based on a 1972 edition of a standard textbook (Glickman 1972), with a capsule description of each:

Simple periodontitis. Chronic inflammation of the gingiva caused by "local irritation" (i. e., plaque and calculus) and associated with horizontal bone loss.

Compound periodontitis. Periodontitis with angular bone destruction due to "local irritation" plus "occlusal disharmony."

Periodontosis. A non-inflammatory degeneration of the supporting periodontal tissues which may be aggravated by occlusal trauma and inflammatory changes.

Occlusal periodontitis (trauma from occlusion). Degenerative and necrotic changes in the supporting periodontal tissues with widening of the periodontal ligament space and angular bone resorption.

Periodontal atrophy (including presenile and disuse atrophy). Reduction in the height of the periodontium with thinning of the periodontal ligament and reduction in its cellularity. Causes of the changes not known, possibly associated with diminished occlusal forces.

In the intervening years, substantial changes have taken place in our understanding of the pathogenesis of the disease. Microbial infections have emerged as the primary and most likely cause of periodontitis (Socransky 1977, Slots 1977a, 1979, 1982), with other factors such as occlusal trauma, hormonal alterations, and leukocyte dysfunctions acting to modify the response of the tissues to infection. An excellent summary of the historical changes that have taken place in the classification of periodontal diseases has been presented by Carranza (1984).

As our understanding of the disease continues to improve, the emphasis on degenerative or atrophic changes is likely to diminish. This will be due to the identification of specific etiologic mechanisms for diseases previously attributed to degeneration for lack of a better explanation. A good case in point is that of periodontosis, now more commonly referred to as juvenile periodontitis, which for many years was considered to be of a non-inflammatory and degenerative nature (Glickman 1972). The information available at this time indicates that inflammation is present, although not clinically prominent, and that *Actinobacillus actinomycetemcomitans* is the most likely etiologic agent (Slots 1976, Newman & Socransky 1977, Tanner et al. 1979, Slots et al. 1980, Listgarten et al. 1981, Ebersole et al. 1982a). However, it is still too early at this time to reclassify periodontitis as a series of specific infections.

Current classifications of periodontitis tend to lump most forms of periodontitis in adults into a single category, *adult periodontitis.* Additional categories have been suggested which represent for the most part assorted forms of the disease occurring in younger patients (Page & Schroeder 1982, Schroeder 1983). Among these are included relatively rare forms of periodontitis such as *juvenile periodontitis,* which has relatively well defined features (Baer 1971, Hørmand & Frandsen 1979, Saxén 1980, Listgarten et al. 1981, Ebersole et al. 1982b, Schroeder 1983, Burmeister et al. 1984), and others with less well-defined characteristics including *prepubertal periodontitis* (Page & Schroeder 1982, Schroeder 1983, Page et al. 1983b, Rateitschak et al. 1984) and *rapidly progressing periodontitis* (Page & Schroeder 1982, Schroeder 1983, Page et al. 1983a, Rateitschak et al. 1984). The latter two categories seem to include a rather haphazard collection of medical conditions that have in common their association with a rapidly progressing periodontitis. Many of these rapidly progressing forms of periodontitis in young individuals are associated with defects in leukocyte function (Page & Schroeder 1982, Genco & Slots 1984).

Clinical aspects of periodontitis

Regardless of their classification, most forms of periodontitis are characterized by the presence of gingival inflammation, pocket formation and loss of alveolar bone and periodontal ligament. There are some situations, however, where this description of periodontitis may be too simplistic if not misleading. For example, following successful treatment of periodontitis and correction of the accompanying anatomic defects it is common for a normal periodontium to become reestablished apically to its original location on the tooth. Any recurrence of gingivitis, even in the absence of further bone involvement, might be defined as a recurrence of periodontitis, since the gingivitis is occurring in the presence of diminished tooth support. Therefore, it may be necessary to differentiate between *periodontitis* and *gingivitis with pre-existing bone loss,* since the clinical implications as well as the microbial etiology may differ significantly. For the purpose of this conference, the emphasis will be on the more prevalent form of periodontitis, the adult form,

Adult periodontitis (AP)

Prevalence and distribution. Adult periodontitis (AP) is considered to have its onset during adolescence and progress throughout life. It is the most common form of periodontitis and has been extensively investigated (Belting et al. 1953, Marshall-Day et al. 1955, Bossert & Marks 1956, Russell 1957, 1967, Schei et al. 1959, Waerhaug 1966, WHO 1978). Epidemiologic studies by Marshall-Day et al. (1955) have indicated a rapid rise in the prevalence of AP between the teenage years and the mid-thirties with a concomitant rise in the prevalence of the disease from under 10% in teenagers to around 90% of the adults in their mid-thirties. After age 40 years, close to 100% of the population was estimated to exhibit signs of AP. Somewhat lower prevalence values have been reported by others in this country (Bossert & Marks 1956, Russell 1957, 1967) and elsewhere (Russell 1967, Schei et al. 1959, Waerhaug 1966, WHO 1978). Some of the discrepancies in the prevalence of AP are due in part to a lack of uniformity in the definition of what constitutes AP. If AP is identified simply by the presence of probing depth recordings of 3 mm or greater, as has been the case in some studies (Page & Schroeder 1982), the prevalence will surely be greater than if more stringent criteria are selected. Unfortunately, no widely accepted criteria have been developed for such prevalence studies. It is clear, however, that the number of patients affected increases with age and that the severity of the disease is related to the presence of microbial deposits on the teeth (Russell 1967, Schei et al. 1959, Waerhaug 1966, WHO 1978).

Data from sizeable populations also reveal that there is a slow, progressive increase in the degree (severity) of periodontal attachment loss with increasing age. This loss of attachment is not evenly distributed within the population, or the dentition. It is clear that some subjects, some teeth and some surfaces are more severely affected at a given point in time than others. In addition, the pattern of tissue loss tends to be bilaterally symmetrical (Miller & Seidler 1942, Loe et al. 1978a, 1978b, Hirschfeld & Wasserman 1978).

While the epidemiologic data suggests a continuous albeit slow progression of the disease involving most teeth, the data from individual subjects indicates that the disease progresses in an episodic fashion and that relatively few teeth and surfaces are actively breaking down at any given time. Furthermore, periods of active disease (i. e., when tissue destruction is actually taking place) may be relatively brief, while the rate of destruction of the affected surfaces during these episodes may be relatively rapid. The pattern of tissue destruction appears to result from repeated episodes of active disease separated by intervals of disease remission and repair, rather than continuous breakdown (Socransky et al. 1984, Listgarten in press).

To understand the underlying cause of this pattern of tissue breakdown, it may be helpful to think of AP as the outcome of an imperfectly balanced host/parasite interaction. As pointed out by Lehner (1982), the development of the oral microbiota and the host (immune) response to it are intimately related. They develop over a number of years beginning at birth. The immune response, in its multiple manifestations, is primarily protective despite its ability to mediate tissue injury.

In conjunction with other host defense mechanisms, such as epithelial barriers, various defense cells (polymorphonuclear leukocytes, macrophages) and the intrinsic ability of host tissues to undergo remodelling and repair, the immune response is able to contain attempts by microbial agents to invade the host tissues, and in some instances to neutralize bacterial toxins.

A number of events, however, may upset this delicately balanced stand-off between the host and its resident microbiota. For example, if regular oral hygiene procedures are suspended, the increase in mass of selected microorganisms may temporarily upset the host/parasite balance and lead to a transient loss of tissue. Resumption of oral hygiene and/or adaptation of the host to the increased bacterial load will result in the restoration of the original *status quo*, but frequently with some degree of residual tissue damage dependent on the amount of repair that occurred. Similar episodes of disease activity conceivably may develop as a result of weakened host defenses rather than bacterial alterations (Listgarten in press).

The symmetry which exists in the anatomy of the natural dentition and its eruption pattern may have an influence on the colonization of the dentition by various microorganisms. It would not be surprising to find some symmetry in the normal colonization pattern of contralateral tooth surfaces or the microbial composition of contralateral periodontal lesions. The combination of anatomic and microbiologic factors more or less symmetrically distributed in the dentition might account for the symmetry of periodontal lesions in affected populations (Hørmand & Frandsen 1979, Burmeister et al. 1984, Miller & Seidler 1942, Loe et al. 1978a, 1978b, Hirschfeld & Wasserman 1978).

It should be noted that the symmetrical distribution of periodontal lesions may not be readily detectable in single subjects who, in fact, may give the erroneous impression that all tooth surfaces are equally likely to develop periodontitis lesions. The apparent randomness of periodontal lesions in individual patients is misleading since population studies have firmly established that periodontitis preferentially affects some teeth and some surfaces. Population studies have also clearly shown that not all subjects are at equal risk to develop periodontitis, and that some subjects are more refractory to treatment of the disease than others. The cause for these differences in the susceptibility to disease among subjects, teeth or individual surfaces remains conjectural. Nevertheless, in designing studies of periodontitis and analyzing tooth surface data, the above characteristics of the distribution of periodontitis lesions must be taken into account.

Pathogenesis of the inflammatory lesion

In health, the tooth is anchored in the jaw bone by the periodontal ligament, a highly vascularized and well innervated ligament of dense collagenous fibers which attaches the cementum lining the root surface to the alveolar bone lining the socket. Most of the root, with the exception of a 1–2 mm zone just apical and more or less parallel to the cementoenamel junction, lies within the bone. The crestal bone and cervical region of the tooth are covered by the gingival tissue which is attached by dense collagenous fibers to the bone as well as the root surface protruding from the socket. The gingiva is also attached to the cervical enamel by a band of junctional epithelium which is continuous with the sulcular epithelium lining the shallow gingival sulcus and the oral epithelium of the gingiva which lines the oral vestibular surface of the gingiva.

The tooth surface adjacent to the gingival sulcus is generally colonized by a thin layer of predominantly gram-positive, facultative micro-organisms that appear to be compatible with periodontal health (Listgarten 1976, Slots 1977b, Listgarten & Helldén 1978). The previously held concept that only a bacteria-free tooth surface is compatible with periodontal health is giving way to the more realistic view that tooth surfaces normally harbor a resident microbial population and that some microbiotas are not only compatible with periodontal health, but in fact help to maintain the healthy status of the tissues by occupying an ecological niche which is no longer available to less desirable micro-organisms. The normal resident microbiota consists primarily of *Streptococcus* and *Actinomyces* species, as well as other microbial species that readily colonize bacteria-free surfaces. When tooth surfaces are cleaned on a regular basis, these micro-organisms become readily reestablished on the freshly cleaned tooth surface, a property which may explain their prevalence in well-maintained dentitions.

An intact epithelial barrier and a high rate of epithelial turnover and surface of desquamation prevent the bacteria from gaining direct access to the tissues. While some bacterial and other exogeneous products may diffuse through the relatively permeable junctional epithelium to reach the underlying gingival connective tissue, normal host defense mechanisms limit the penetration of these products and their potentially damaging effects on the tissues (Listgarten 1972).

The narrow band of lymphocytes which frequently parallels the junctional epithelium, even in clinically healthy dentitions, is a morphological reflection of this host/parasite interaction. Gingival connective tissues totally free of inflammatory cells are extremely rare, even in germfree animals (Listgarten & Heneghan 1971, 1973). In addition, polymorphonuclear leukocytes in low numbers are generally observed within the junctional epithelium where they are presumably attracted through the chemotactic effect of bacterial products and activated components of the complement cascade.

Although Page & Schroeder (1976)

have characterized the lymphocyte-rich inflammatory infiltrate as an "early lesion", it may reflect the predominant status of clinically healthy gingiva and represent a relatively stable feature of the gingival tissue, analogous to the lymphoid cells lining the remainder of the healthy gastrointestinal tract. Depending on the degree of lymphocytic infiltration of the subepithelial connective tissue and of PMNs in the junctional epithelium, periodontal probing may result in limited penetration of the probe into the infiltrated junctional epithelium (Listgarten 1980, Robinson & Vitek 1979). Despite transient fluctuations which may take place in the composition of the resident microbiota or the host response to its presence, the status of the tissues may remain stable over long periods of time without further replacement of the collagenous tissue framework by inflammatory cells.

If environmental factors, for example plaque control measures, are altered so that changes are allowed to occur in the quantity and composition of the resident microbiota (Slots et al. 1978, Loesche 1978, Syed & Loesche 1978), the resulting conditions may shift the normal host/parasite balance in favor of the microbiota. In addition to net increases in various bacterial products, new species may be introduced with which the host is not prepared to cope. The outcome may lead to an intensified inflammatory reaction with an increased influx of PMNs into the junctional epithelium and lymphocytes into the subjacent connective tissue, the appearance of plasma cells which may become the dominant cell of the inflammatory infiltrate, and concomitant destruction of the gingival collagenous fibers (Page & Schroeder 1982, 1976). Clinically, these tissue changes could produce gingival redness and swelling, and bleeding during periodontal probing. The latter may be due in part to further penetration of the tissues by the probe tip during probing as a result of more extensive tissue inflammation (Abrams et al. 1984) and consequent rupture of the dilated, convoluted capillary bed adjacent to the junctional epithelium.

It may be possible for the host to adapt to the changed conditions so that a new equilibrium is reestablished between the increased mass of bacteria, newly acquired microbial species and the host defenses. Conceivably, this equilibrium may be reached in the presence of an increased volume of infiltrated gingival tissue, a predominance of plasma cells, further loss of collagen on the tooth side of the gingiva, and a dilated and convoluted vascular plexus subjacent to the junctional epithelium. The tissue changes may be accompanied by a net increase in the rate of outflow of cells and fluid from the sulcus. Thus the new host/parasite equilibrium may become established under conditions which are no longer compatible with a healthy periodontium, but instead tend to maintain a state of chronic gingivitis.

Transient fluctuations in the host/parasite equilibrium may result in cycles of either diminished or increased intensity of the inflammatory response. In one case the tissues may undergo spontaneous repair and in the other further breakdown. Thus, cyclical changes can be expected and, indeed, have been reported in the degree of gingival inflammation (Suomi et al. 1971, Hoover & Lefkowitz 1965). Given enough time the periodic exacerbations of the inflammatory process may lead to further tissue damage including loss of dentogingival fibers and crestal bone. As soon as the destructive process affects the collagen fibers inserted into root cementum, the gingivitis, according to current terminology, becomes a periodontitis.

Periodontitis

If microbial or other environmental changes develop, for example the appearance of new microbial species (Slots 1977a, 1979, Tanner et al. 1979), occlusal trauma (Lindhe & Nyman 1977, Zander & Polson 1977), development of subgingival calculus, and the host becomes unable to deal with these changes effectively, the periodic imbalances in the otherwise predominantly stable host/parasite equilibrium may increase in frequency and possibly in duration. Furthermore, as periodontal support is lost through these periodic flare-ups, anatomic alterations, for example the development of deep pockets, exposure of furcations or the appearance of secondary occlusal trauma may accelerate the frequency, intensity and/or duration of episode of tissue breakdown. A vicious circle is created which, unless interrupted, may lead to eventual tooth loss.

The transition from health to clinically detectable gingivitis and from the latter to periodontitis is subtle and not precisely identifiable. It is characterized by prolonged periods of remission and even spontaneous reversals of the disease process (Socransky et al. 1984). Health and different stages of the disease are able to coexist in individual patients and on individual teeth. Yet, it is clear that some subjects are more susceptible to periodontitis than others, as evidenced by younger individuals who exhibit localized or generalized destruction of the periodontal tissues far in excess of that observed in other subjects of the same age and sex (Page & Schroeder 1977). Likewise, some patients, following treatment, are far more susceptible than others to recurrences of periodontitis, with relatively few individuals accounting for the bulk of the surfaces with disease recurrence (Hirschfeld & Wasserman 1978, Lindhe & Nyman 1984, Listgarten & Levin 1981, Listgarten et al. 1984).

The histopathologic features of inflammatory periodontal disease have been studied by Page and Schroeder (1976, 1982) among others, and will not be reviewed in detail in this presentation. These authors suggested four distinct stages in the inflammatory process. These include the *initial lesion,* an inflammatory lesion characterized by vascular dilation and increased permeability to fluid and cells from the blood. The *early lesion* is identified by a lymphocyte-rich infiltrate which develops adjacent to the junctional epithelium, at the expense of the local collagenous fiber network which is destroyed. It may exhibit features of the initial lesion as well. The *established lesion* is a further extension of the early lesion with plasma cells becoming the dominant cell of the inflammatory infiltrate. Further collagen destruction and epithelial proliferation into the infiltrated connective tissue are also features of this stage. The *advanced lesion* is typical of periodontitis and includes all the features of the established lesion, but in addition features evidence of bone destruction, pocket formation and further apical migration of the junctional epithelium. While the terminology used by Page and Schroeder suggests a series of progressive stages which develop in a well-defined chronological sequence, these stages may become arrested and remain stable over prolonged periods of time. In addition, spontaneous or treatment-induced reversals may result, for example, in an "early" lesion replacing an "established" lesion (Listgarten et al. 1978).

Ideally, clinical health implies the complete absence of an inflammatory infiltrate. Practically, however, Page and Schroeder's *initial* and even *early lesion* may be identifiable in tissues from sites that appear clinically healthy. Increased vascular permeability to cells and fluid and a lymphocytic infiltrate adjacent to junctional epithelium may be the most common if not the normal state and one which may remain stable over extended periods of time. Tissues with gingivitis are more likely to exhibit *early* and *established lesions,* while sites with periodontitis include predominantly *established* and *advanced lesions,* both of which are characterized by plasma cell-dominated inflammatory cell infiltrates.

Differences in the histopathologic features of different stages in the disease process are accompanied by differences in the composition of the neighboring microbial population. For example, the microbiota at healthy sites includes predominantly non-motile, gram-positive facultative cocci and rods with *Streptococcus* and *Actinomyces* species predominating (Listgarten 1976, Slots 1977b, Listgarten & Hellden 1978). Gingivitis (Slots et al 1978, Syed & Loesche 1978) and periodontitis (Slots 1977a, 1979, 1982, Tanner et al. 1979) are associated with more complex microbiotas which tend to comprise increasing proportions of more motile, gram-negative and anaerobic species. This shift in the microbial composition is a general trend which may not apply to all individuals who develop periodontitis. While certain micro-organisms appear to be more strongly associated with AP lesions than others, for example *Bacteroides intermedius, Bacteroides gingivalis, Wolinella recta, Actinobacillus actinomycetemcomitans* and spirochetes, to name a few, the reports in the current literature reveal insufficient consistency in the composition of the microbiota at diseased sites to implicate any of these, singly or in groups, as likely etiologic agents of adult periodontitis (Slots & Genco 1984, Slots 1984). Few studies have examined both the histopathological characteristics of a diseased site and the adjacent microbiota. In one report, an association was demonstrated in humans between spirochetes and the presence of a plasma cell-dominated inflammatory infiltrate in the adjacent tissue (Listgarten et al. 1978). However, there is a lack of similar information for other microbial forms.

Like the microbiological profile of adult periodontitis, the immunological profile of these patients lacks any consistency that would help implicate one or more micro-organisms as potential causative agents (Ranney et al. 1981, Tew et al. 1981, Ebersole et al. 1982, Doty et al. 1982, Taubman et al. 1982). Some correlations have been reported between adult periodontitis and elevated antibody titers to *B. gingivalis.* However, they are not sufficiently reproducible and predictable to implicate *B. gingivalis* as the major cause of adult periodontitis (Genco & Slots 1984). The lack of specific antibody titer increases in AP may be due in part to polyclonal activation which may produce generalized rather than specific increases in antibody titers (Smith et al. 1980, Bick et al. 1981).

Disease activity and bacterial invasion

The major stumbling block to a better understanding of the microbial etiology of adult periodontitis and the development of clinically useful diagnostic tests remains the lack of an *absolute criterion of disease activity,* i. e., a means of identifying precisely all instances of disease activity, including their exact beginning as well as their termination. In the present context, disease activity is used to indicate periods of actual tissue destruction caused by a temporary imbalance in the host/parasite equilibrium. If one accepts that most of the time tissue destruction is *not* ongoing, then clinical or laboratory findings collected on a random basis are likely to be representative of periods of disease remission rather than disease activity. They may reflect the results of previous episodes of disease activity that have left some residual anomalies in the anatomic, microbiologic and other characteristics of the affected dentition. However, they may not be an accurate reflection of the status in effect during the periods of disease *activity* or actual tissue destruction.

In recent years, bacterial cells within periodontal tissues have been reported by numerous investigators (Listgarten 1965, Heylings 1967, Frank & Voegel 1978, Frank 1980, Saglie et al. 1982a, 1982b, Gillett & Johnson 1982, Courtois et al. 1983, Allenspach-Petrzilka & Guggenheim 1982, 1983, Carranza et al. 1983, Christersson et al. 1983, Sallay et al. 1982, 1984, Manor et al. 1984, Sanavi et al. 1985). In most cases these findings have been interpreted as evidence of bacterial invasion of the tissues. It has been suggested that such episodes of bacterial invasion may be the underlying cause of the elusive episodes of disease activity which, through cumulative damage, lead to the progressive destruction of periodontal support.

With the exception of acute necrotizing ulcerative gingivitis (Listgarten 1965, Heylings 1967, Courtois et al. 1983), where practically pure cultures of spirochetes occur within the tissues, and two reports, one dealing with a case of adult periodontitis (Allenspach-Petrzilka & Guggenheim 1983), and one with a case of juvenile periodontitis (Saglie et al. 1982b), the reports in the literature dealing with disease in humans indicate a rather haphazard distribution of various bacterial morphotypes within the tissues. This random pattern of microorganisms within tissues suggests that the micro-organisms have been passively introduced, either as a result of

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normal daily functions such as chewing or oral hygiene procedures, or during manipulation of the tissues during the biopsy procedure or microscopic processing. It is well-known that bacteria are frequently introduced into the gingival tissues in the course of daily functions or as a result of dental procedures (Sconyers et al. 1973, Silver et al. 1977, Carroll & Sebor 1980, Guntheroth 1984). These events may result in transient bacteremias which have been implicated as a chief cause of infective endocarditis. However, there is no evidence to indicate that translocation of bacteria from the gingival sulcus or pocket is in any way associated with subsequent tissue invasion. It is likely that normal host defense mechanisms rapidly clear the bacterial intruders without any further damage to the tissues (Silver et al. 1975). The random distribution of bacteria in many of the reports of so-called bacterial invasion (Frank & Voegel 1978, Frank 1980, Saglie et al. 1982a, Gillett & Johnson 1982, Carranza et al. 1983, Manor et al. 1984) suggests a passive introduction of bacteria into the tissues rather than a *bona fide* invasion.

Since, by definition, bacterial invasion is dependent on bacterial proliferation as well as bacterial dissemination, one might expect to observe localized microcolonies in the case of relatively immobile species, or, if they are motile, widespread dissemination of morphologically homogeneous microorganisms representing one or possibly several invading bacterial species. Indeed, experimentally created infections support this assumption, with invading bacteria appearing as morphologically homogeneous populations rather than a haphazard mixture of different cell types (Sallay et al. 1982, 1984, Allenspach-Petrzilka & Guggenheim 1982, Sanavi et al. 1985). The concept of repeated episodes of tissue invasion by bacterial pathogens to explain the episodic nature of periodontitis is an attractive one. Unfortunately, with the possible exceptions of ANUG and juvenile periodontitis, there is no reliable evidence that this is, indeed, the case

In summary, periodontitis is an inflammation of the periodontal tissues which includes destruction of the periodontal ligament and associated alveolar bone. Its primary etiology is due most likely to an imbalance in the host/parasite equilibrium which is normally compatible with an intact periodon-

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tium. This imbalance may be precipitated by quantitative and qualitative alterations in the periodontal microbiota and/or altered responses of the host to this microbial population. Tissue destruction appears to occur in an episodic manner. These periods of disease activity appear to be relatively short-lived, but their onset, termination and exact duration cannot be preciself determined at this time. It is likely that while the overall rate of loss of tooth support is slow, the rate of loss during periods of active tissue breakdown is relatively rapid. Prolonged periods of remission may exist between periods of active disease during which no further destruction or even partial repair may occur. While episodes of active disease may appear to occur at random in individual patients, epidemiologic data suggests a symmetrical distribution in the pattern of tissue destruction and a differential susceptibility of different subjects, tooth types and individual tooth surfaces to the disease process.

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Zusammenfassung

Die Pathogenese der Parodontitis

Die Parodontitis ist eine entzündliche Krankheit des Parodonts, die durch eine fortschreitende Destruktion des Zahn-Stützgewebes gekennzeichnet ist. Bei ihrer primären Atiologie spielen mangelhaft definierte Serien mikrobieller Infektionen eine Rolle, Infektionen, die sich aus einigen der mehr als 300 Spezies bestehenden Mundflora zusammensetzen. Im allgemeinen wird angenommen, dass die Krankheit in Perioden fortschreitet. Relativ kurze Perioden schneller geweblicher Destruktion wechseln mit darauf folgenden reparativen Phasen und verlängerten Interventionsperioden von Krankheitsremissionen. Trotz der offenbar zufälligen Verteilung der krankheitsaktiven Episoden, zeigt die durch sie entstehende knöcherne Lysis ein symmetrisches Erscheinungsbild. Die Taschenformation ist bei mehreren Parodontitisformen die gleiche, obwohl die Verteilung der am schwersten betroffenen Zähne und Zahnoberflächen bei den verschiedenen Krankheiten verschieden ist (z. B. juvenile Parodontitis im Vergleich zu der Parodontitis

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des Erwachsenen oder der schnell fortschreitenden Parodontitis).

Mehrere Rapporte haben gezeigt, dass bakterielle Zellen in den Taschenwänden parodontischer Läsionen gefunden werden können. Die Translokation von Bakterien vom Taschenmilieu in das Gewebe kommt oft vor, wie durch das häufige Vorkommen von Bakteriohämien bei Patienten mit Parodontitis anlässlich rel. unbedeutender Vorkommnisse, wie beim Kauen und bei oralen Hygieneanstrengungen, gezeigt werden kann. Es ist jedoch wichtig, zwischen dem passiven Einsickern von Bakterien in die parodontalen Gewebe und der massiven Invasion einer akuten Infektion zu unterscheiden, da die pathologischen Folgen recht unterschiedlich sein können.

Résumé

Pathogenèse de la parodontite

La parodontite est une maladie inflammatoire du parodonte qui est caractérisée par une destruction progressive des tissus de soutien de la dent. Son étiologie primaire est une série mal définie d'infections microbiennes qui peuvent n'inclure que certaines des plus de 300 espèces bactériennes couramment observées dans la cavité buccale. La maladie progresserait périodiquement par épisodes relativement courts de destruction tissulaire rapide suivis par quelque réparation, et des périodes intermittantes prolongées de rémission de la maladie. Malgré la distribution apparemment randomisée des épisodes d'activité de la maladie, la destruction tissulaire qui en résulte montre un modèle symétrique de perte osseuse avéolaire et de formation de poche qui est commun à différentes formes de parodontite, bien que la répartition des sites et des surfaces les plus affectés peut varier avec les maladies (parodontite juvénile par rapport à la parodontite de l'adulte ou la parodontite progressant rapidement).

Différentes études ont mis en évidence des bactéries dans la paroi de la poche de lésions avec parodontite. Le passage de bactéries dans les tissus depuis la poche environnante est fréquent comme le démontre l'apparition courante de bactériémie chez les patients avec parodontite après des événements relativement mineurs tels que la mastication ou les mesures d'hygiène buccale. Cependant il est important de distinguer la pénétration passive des bactéries dans le tissu parodontal et l'invasion franche qui peut apparaître dans une infection aiguë puisque les implications pathologiques peuvent être très différentes.

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