

Diabetes and Oral Health—Current Concepts Regarding Periodontal Disease and Dental Caries

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Abstract

There are a number of important oral manifestations of diabetes. Periodontal disease and dental caries are the most common oral diseases, and both are modified when diabetes is present. There is an increased prevalence of periodontal disease in patients with diabetes, and periodontal disease can adversely affect glycemic control. Root caries also is more prevalent in patients with diabetes. The sequelae of both periodontal disease and dental caries are infection, pain, tooth loss, and reduced masticatory function. Non-oral health care providers who treat patients with diabetes must be aware of the oral manifestations of the disease and inform patients that ideal oral health is part of comprehensive management of diabetes.

Keywords

Diabetes complications, periodontal disease, dental caries, glycemic control

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The increased morbidity and mortality associated with diabetes are well known to health care providers. Retinopathy, nephropathy, macrovascular disease, neuropathy, and poor wound healing can have a major impact on the lives of patients with diabetes. These complications take an enormous personal and financial toll.

In addition to these recognized complications, the oral cavity and contiguous structures can be dramatically affected by diabetes. These oral complications are not widely recognized by non-dental health care providers, but can have important effects on quality of life of patients with diabetes, and can also directly and indirectly effect glycemic control.

There are a wide range of oral manifestations that have been reported in patients with diabetes. These include increased extent and severity of periodontal disease, changes in the prevalence of dental caries, burning mouth syndrome, *Candida* infection, xerostomia, altered taste sensation, altered tooth eruption, and hypertrophy of the parotid glands. Non-dental health care providers and patients need to be aware of the changes in the oral cavity associated with diabetes, emphasize the importance of an oral/dental evaluation when the diagnosis of

diabetes is first made, and make appropriate referral if the patient reports a problem. Dental professionals must be familiar with the range of oral disorders observed in patients with diabetes, and how these problems should be managed in patients with the disease. This review will focus on the two most common oral diseases (periodontal disease and caries), how these disorders are modified in patients with diabetes, and how they can affect patient management.

Periodontal Disease

The most common oral complication of diabetes is periodontal disease. The periodontal diseases are a group of inflammatory disorders of the supporting tissues of the teeth, which includes the gingiva (mucosal tissue about the teeth), cementum (covering the roots of the teeth), the periodontal ligament, and the alveolar bone into which the teeth are anchored. The pathology of periodontal disease is an inflammatory lesion induced by the dental plaque biofilm found at the opening of and within the gingival crevice. Beginning as an inflammation of the gingiva, the inflammatory lesion can extend to involve the alveolar bone. If the lesion continues to progress, pronounced loss of alveolar bone leads to tooth mobility and tooth drifting, abscess formation and ultimately tooth loss.

Figure 1: Healthy Periodontium (A) and Periodontitis (B)



A: Inflammation is minimal and there is no loss of osseous support; B: periodontitis evidence of plaque and calculus deposits, tissue inflammation, drifting and over-eruption of teeth due to loss of osseous support.

Reviews have demonstrated that the extent and severity of periodontitis is greater in patients with diabetes, and diabetes is the only systemic disorder that is a recognized risk factor for periodontitis¹⁻⁴ (see *Figure 1*). Taylor and Borgnakke¹ reported that more than 75 % of studies (13 of 17) published from 1960 to 2007 that examined periodontal disease as a complication of diabetes found that periodontitis was more severe when diabetes was present. A review by Chavary and colleagues² included studies published between 1980 and 2007. Fifty-five percent of the cross-sectional studies demonstrated significantly greater clinical periodontal disease when diabetes was present. Eight longitudinal studies were also reviewed, four of these examined progression of disease, and three demonstrated that periodontitis progressed more rapidly in patients with diabetes. Similarly, Preshaw and colleagues concluded that individuals with diabetes are at three times the risk for periodontitis compared to those without the disease.³ Papapanou and Lalla reviewed the interrelationship of diabetes and periodontitis, and concluded that ideal care for patients with diabetes would include an emphasis by physicians on the importance of oral health, and when periodontitis is

present, establishment of a collaborative relationship between medical and dental providers.⁴

Of recent interest, the relationship between diabetes and periodontitis has been shown to be bidirectional. That is, the presence of periodontal disease can adversely affect glycemic control in diabetes. Evidence also suggests that the presence of periodontitis is a risk factor for development of complications of diabetes.

A meta-analysis by Simpson et al.⁵ demonstrated that oral hygiene instruction and root planing and scaling, which is a thorough debridement of the dental plaque at the orifice and in the gingival crevice, as well as removal of calcified deposits (calculus) on the root surfaces of the teeth, in the absence of other treatment, resulted in a decrease in glycated hemoglobin (HbA_{1c}) of 0.4 % after three months. A similar conclusion was reached by Teeuw and colleagues.⁶ These analyses provide a clear rationale for all patients with newly diagnosed diabetes, or patients who have a diagnosis but demonstrate poor metabolic control, to have an oral evaluation that includes a periodontal examination. If periodontitis is present, periodontal therapy is indicated. This will improve the health of the supporting structures of the teeth, halt or slow the progression of periodontal disease (and thereby maintain masticatory function), and may improve glycemic control.

Other studies suggest the importance of periodontal disease as a risk factor or risk indicator for long-term outcomes of diabetes. These studies have examined the influence of periodontitis on the subsequent development of recognized complications of diabetes. Shultis and colleagues⁷ evaluated the progression of renal disease in members of the Gila River community of Native Americans. A total of 529 individuals were classified according to the severity of their periodontal disease (none/mild, moderate, severe, or edentulous). These individuals did not display renal disease at the beginning of the evaluation period, and follow-up information was available for up to 22 years. During that period 193 developed macroalbuminuria and 68 developed end-stage renal disease. The occurrence of renal disease increased with an increase in the severity of periodontal disease at baseline. In an adjusted model, compared to the individuals with none/mild periodontitis, for those with moderate periodontitis, severe periodontitis, or who were edentulous, the risk of developing macroalbuminuria was 2.0, 2.1 and 2.6, respectively ($p=0.01$); for end-stage renal disease, the risk was 2.3, 3.5 and 4.9 ($p=0.02$). The authors concluded that the presence of periodontitis predicted the development of nephropathy in individuals with type 2 diabetes (see *Figure 2*). The question they posed was whether treatment of periodontal disease would reduce this risk.

In another report based on data from that same community, the relationship of the presence of periodontal disease to mortality from cardiovascular or renal disease was examined.⁸ Periodontal disease was classified as none/mild, moderate and severe. Six hundred and twenty-eight individuals were included, the mean period of follow-up was 11 years, and there were 204 deaths. To normalize the findings, death were expressed as the number per 1,000 years of follow-up. The none/mild periodontitis group was 3.7, the moderate periodontitis group was 19.6, and the severe periodontitis group was 28.4. Deaths from both ischemic heart disease ($p=0.04$) and nephropathy ($p<0.01$)

were predicted by the presence of periodontal disease at baseline. Assessing the relative risk of death from either cause in a fully adjusted model, the individuals with severe periodontitis were at 3.2 times increased risk as compared to the none/mild and moderate periodontal disease groups.

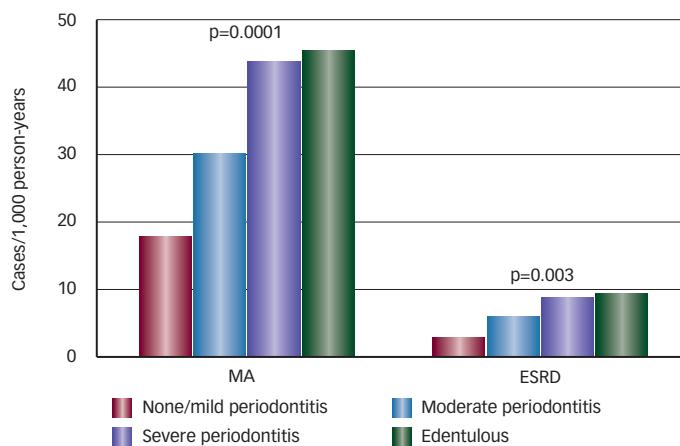
Additional evidence linking periodontal disease and diabetes comes from two studies that examined the relationship of the presence of baseline periodontal disease to the subsequent onset of diabetes,⁹ and baseline periodontal disease to the subsequent change in HbA_{1c}.¹⁰ Using data from NHANES I, Demmer and colleagues⁹ stratified the severity of periodontal disease at the baseline examination into six categories, and then used data from a subsequent examination to identify diabetes. A total of 9,296 individuals without diabetes comprised the population evaluated at baseline, and logistic regression was used to determine the odds ratio of developing diabetes. The mean period of follow-up was 17 years. Compared to periodontally healthy individuals, no increase in risk for development of diabetes was observed in the two lowest periodontal disease severity groups, but the odds ratios of developing diabetes was 2.26 for group 3, 1.71 from group 4, 1.50 from group 5, and 1.30 for edentulous individuals.

The increase in HbA_{1c} in individuals without diabetes, but with periodontitis, has also been assessed.¹⁰ Participants were categorized based on the severity of periodontal disease at baseline, and the outcome was the change (increase) in HbA_{1c} after five years. In a full adjusted model, compared to the group with the least periodontal disease, the group with the greatest severity of disease demonstrated a five-fold increase in absolute HbA_{1c}. Furthermore, the mean increase in HbA_{1c} in study participants without periodontal disease at baseline, who did not progress to periodontal disease over the five years, was only 0.005%. In contrast, the participants with advanced disease at baseline, who demonstrated progressive disease over the five-year study period, the mean increase in HbA_{1c} was 0.143%.

Collectively, these studies suggest that the relationship between diabetes and periodontitis is more important than previously recognized. Patients with diabetes should be evaluated for periodontal disease at the time of diagnosis, and thereafter should be seen regularly for dental care. Effective oral health care will reduce the accumulated biofilm and periodontal inflammation, which will result in less dental disease, ultimately retention of the dentition, and can contribute to improved glycemic control. In addition, dental professionals who care for patients with advanced periodontal disease, or periodontal disease that progresses rapidly, should question whether these patients might be at risk for diabetes.

Greater extent and severity of periodontal disease is the most common oral complication of diabetes. Nevertheless, other oral manifestations of diabetes occur, and there appears to be important etiologic linkages between these different oral disorders. Specifically, published data suggest that a specific type of dental caries that affects the roots of teeth may be greater in patients with diabetes.

Figure 2: Development of Macroalbuminuria and End-stage Renal Disease in Patients with Diabetes, Stratified by the Severity of Periodontitis



ESRD = end-stage renal disease; MA = macroalbuminuria.

Source: Modified from Shultis, et al., 2007.⁷ Copyright © 2011 American Diabetes Association, Inc.

Dental Caries

Dental caries is the indirect result of the metabolism of fermentable carbohydrates by specific oral bacteria (*Streptococcus mutans*, *Lactobacillus* species), with the by-product of that metabolism (lactic acid) acting on a mineralized substrate (the dentition). The result is the demineralization of the teeth, ultimately leading to frank cavitation. Advanced dental caries is associated with involvement of the neurovascular tissue within the pulp chamber of the teeth, resulting in pain and abscess formation. Endodontic (root canal) therapy or tooth extraction are then needed. Caries can be classified as coronal, affecting the crowns of the teeth, and root caries, which affects the usually unexposed roots of the teeth.

As reported in the literature, the relationship of dental caries to diabetes is controversial.^{11–13} Increased caries, no differences and decreased caries have been reported. The available evidence suggests that coronal caries (involving the crown portion of the teeth normally visible in the mouth), does not differ between individuals with diabetes and those without the disease. It is important to emphasize that the studies examining this question do not always consider the many variables that influence the caries experience. A patient with type 2 diabetes who is overweight or obese may have a large intake of cariogenic food (fermentable carbohydrates). In contrast, a patient who is metabolically well-controlled is likely to have a limited intake of such foods. The caries experience of individuals in these two situations will likely differ markedly.

A number of reports offer insight into this relationship. No differences were seen in the coronal caries experience of adult patients with diabetes versus individuals without diabetes, but those patients with diabetes did demonstrate an increased rate of root caries.¹⁴ Root caries can develop when the root surface is exposed as the gingival margin recedes. This is often seen in older individuals with a history of periodontal disease. Periodontal disease is characterized by loss of supporting bone about the teeth, which will result in greater exposure of root surfaces to the oral cavity.

Figure 3: The Relationship of Increased Extent and Severity of Periodontitis and the Development of Root Caries in Patients with Diabetes

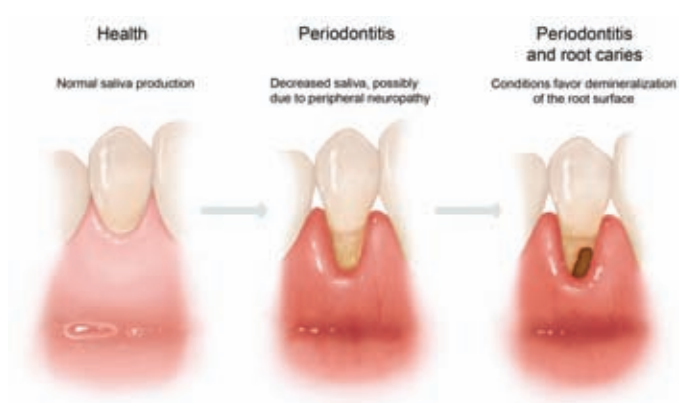


Figure 4: Root Caries on Mandibular Anterior Teeth in a Patient with Diabetes



Demineralization is also present on the incisal edges of the teeth due to exposure of the dentin. The patient has reduced salivary flow. Source: Courtesy of Dr Angus Walls, Newcastle University, Newcastle upon Tyne, UK.

Therefore, the increase in root caries may be secondary to the increased prevalence of periodontitis in patients with diabetes. With loss of bone and periodontal ligament about the teeth, the gingival tissues recedes, exposing the previously covered root surfaces. The root surface, which is covered by cementum, is more susceptible to demineralization than the enamel that covers the crowns of the teeth (see *Figure 3*).

An important consideration when examining caries development is salivary flow. Saliva is an exocrine secretion. The mixing of saliva with a bolus of food begins the digestive process. Saliva also has a critical buffering role in the oral cavity. Saliva has the capacity to buffer the acid produced by the action of bacteria on fermentable carbohydrates. Saliva production has been reported to be reduced in patients with diabetes with poor metabolic control,^{15,16} and a murine model has demonstrated that hyperglycemia and reduced salivary flow leads to demineralization and dental caries.¹⁷ Salivary flow is under the direct and indirect control of the autonomic nervous system, and therefore

reduced salivary flow may be a consequence of peripheral neuropathy. When salivary flow was examined in older individuals with and without diabetes, no differences were observed when other modifying factors were not present. However, a side effect of many medications is reduced salivary flow, and this effect was exacerbated when diabetes was present.¹⁸ This effect may be more pronounced in older individuals who are at risk for root caries (see *Figure 4*). Self-care, professional prophylaxis, and restoration of root surfaces that show evidence of demineralization or be at risk for demineralization, are the primary preventive and therapeutic approaches.

Interprofessional Care and Patient Education

Unfortunately, oral and dental health are not fully integrated into the health care management of patients with diabetes. Non-oral health care professionals lack general knowledge about the importance of oral health care in the spectrum of diabetes. Only half of the physicians surveyed stated that they referred their patients with diabetes for a dental evaluation, and two-thirds were unaware that periodontal disease could adversely affect metabolic management in patients with diabetes.¹⁹ Furthermore, general dentists in both the US and New Zealand reported a general lack of knowledge regarding diabetes, which led to a more passive and not active role in managing their patients with diabetes.^{20,21} This lack of knowledge was even more pronounced for dental hygienists, with more than three-quarters reporting a lack of knowledge of the potential impact of diabetes on the delivery of oral health care services.²²

Evidence suggests that patients with diabetes do not access oral health services as often as individuals without diabetes. Macek and colleagues assessed the percent of patients with diabetes who visited different health care providers, stratified by gender.²³ The percent of male patients who visited a medical provider for care of their diabetes, a medical provider for podiatric care, for eye care and for dental care were 82.0, 72.6, 67.8, and 64.4 %, respectively. For women, the percentages were 83.8, 69.6, 64.6, and 57.3 %. Another study by the same authors reported that patients with diabetes and periodontitis have a lower frequency of dental visits compared to individuals with periodontitis but without diabetes.²⁴ The reasons for the disparity were not explored, but may include a lack of awareness on the part of patients with diabetes about the oral complications of the disease, and a perceived lack of time for this additional health care activity, when patients are busy with management of their diabetes. In another study, knowledge about oral health among patients with diabetes was generally fair to poor. Less than half of those surveyed were able to answer all basic questions about the relationship of oral health and diabetes.²⁵

A recent weighted survey of patients with diabetes revealed a lack of understanding on the part of patients about oral complications of diabetes, and how dental disease fits into the spectrum of diabetes complications. More than half of the respondents reported a dental or 'gum' problem, yet nearly 60 % of respondents were unconcerned about oral disease. More than one-third were unaware of the linkage between periodontal disease and diabetes.²⁶

Conclusions

Diabetes is the only systemic disease that is recognized as a risk factor for periodontitis, and evidence is accumulating to suggest that

periodontitis can both adversely affect glycemic control in patients with diabetes, and can identify patients at increased risk for morbidity and mortality associated with diabetes. One of the consequences of periodontitis is loss of alveolar bone about the teeth. This leads to soft tissue recession, and exposure of the root surfaces of the teeth. These surfaces are susceptible to tooth demineralization, specifically root caries. These facts, as well as the identification of other oral disorders associated with diabetes, suggests the importance of oral health care as part of the comprehensive care for individuals with diabetes.

Nevertheless, studies indicate that individuals with diabetes do not access oral health care as often as individuals who do not have diabetes and have limited knowledge about the relationship of oral health and diabetes. This disparity may relate to the amount of time required to manage other aspects of the disease, or the lack of awareness of oral complications of diabetes by primary health care providers.

The International Diabetes Federation has published a Guideline for Oral Health for People with Diabetes.²⁷ This document listed five

recommendations for non-oral health care providers regarding oral health care for persons with diabetes. These include:

1. On an annual basis, ask if the person follows recommended guidelines for oral self-care, and has regular visits to a dental professional.
2. On an annual basis, ask if the person notices signs of periodontal (gum) disease, including bleeding with tooth brushing and gums that appear red and/or swollen.
3. Emphasize the importance of oral self-care and that seeing a dental professional on a regular basis is part of comprehensive care of diabetes.
4. If signs and symptoms of gum disease are reported, persons should be referred for professional dental care.
5. Provide an explanation of why it is important for persons with diabetes to maintain a healthy mouth, and treat gum disease when it is present.

Appropriate oral health care must be emphasized as part of comprehensive health care for individuals with diabetes. The result will be improved oral health, maintenance of normal masticatory function, and improved general health of patients with diabetes. ■

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