Periodontitis and diabetes

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Key points

- Provides an update on knowledge on the links between diabetes and periodontitis.
- Explains the current terminology used to describe blood glucose and glycated haemoglobin levels.
- Considers the role of the dental team in the overall management of patients with diabetes and periodontitis in the context of recommendations from professional and scientific organisations on this topic.

Abstract

Periodontitis and diabetes are complex chronic diseases, linked by an established bidirectional relationship. Risk for periodontitis is increased two to three times in people with diabetes compared to individuals without, and the level of glycaemic control is key in determining risk. In people who do not have diabetes, periodontitis is associated with higher glycated haemoglobin (HbA1c) and fasting blood glucose levels, and severe periodontitis is associated with increased risk of developing diabetes. In people with type 2 diabetes, periodontitis is associated with higher HbA1c levels and worse diabetes complications. Treatment of periodontitis in people with diabetes has been shown to result in improved glycaemic control, with HbA1c reductions of 3–4 mmol/mol (0.3–0.4%) in the short term (3–4 months) post-treatment. Given that treatment of periodontitis results in clinically relevant reductions in HbA1c, the dental team has an important role in the management of patients with diabetes. Improved interprofessional working in relation to diabetes and periodontitis has been advocated by professional and scientific organisations, though practical and systemic barriers make this challenging. This paper reviews current evidence linking periodontitis and diabetes, and considers the role of the dental team in the wider context of management of patients with diabetes and periodontitis.

Introduction

Periodontitis and diabetes are highly prevalent, chronic, non-communicable diseases that present significant public health challenges in populations around the world. The links between the two diseases have been recognised by dental professionals for many years, particularly following descriptions of periodontitis as the 'sixth complication' of diabetes (after the classic diabetes complications of retinopathy, neuropathy, nephropathy, macrovascular and microvascular disease including cerebrovascular disease and altered wound healing) that were published in the early 1990s.[1] We now recognise that the associations between the two diseases are more complex than this, and there is clear evidence of a bidirectional relationship between diabetes and periodontitis, with each having negative impacts on the other.

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Diabetes

Diabetes is a metabolic disorder of multiple aetiology that is characterised by chronic hyperglycaemia (elevated blood glucose levels) with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both.[2] Hyperglycaemia leads to development of the complications associated with diabetes that arise from long-term damage, dysfunction and failure of various organs and body systems that impact on wellbeing and quality of life. Diabetes has significant effects on multiple body systems and organs, including the cardiovascular and circulatory system (cardiovascular disease), the kidneys (nephropathy), the brain and cerebral circulatory system (cerebrovascular disease, stroke, cognitive dysfunction), the lower limbs (peripheral vascular disease, diabetic foot), immune system (increased risk of infections), and eyes (retinopathy). Early symptoms can include thirst, polyuria, blurring of vision and weight loss. A diagnosis of diabetes can be made following a random venous plasma glucose test, a fasting plasma glucose test, a two-hour plasma glucose tolerance test following 75 g oral glucose, or a non-fasting glycated haemoglobin (HbA1c) measurement.

The units used to describe plasma glucose levels vary in different countries: in the UK, millimoles glucose per litre of plasma (mmol/l) is the standard unit of measurement, whereas in other parts of the world (including the USA and some European countries), milligrams glucose per decilitre of plasma (mg/dl) is used. The World Health Organisation (WHO)[3] defines

fasting plasma glucose concentrations as:

- Impaired fasting glucose: 6.1 to 6.9 mmol/l
- Diabetes: 7.0 mmol/l and above.

As part of the management of patients with diabetes, the aim is to achieve blood glucose concentrations that are as close as possible to non-diabetic values, and these can be monitored by patients on a regular basis as part of their self-care. Target levels are individual to each person and ideally should be agreed between the patient and the diabetes care team, and regularly re-evaluated as part of ongoing diabetes management.

The term 'prediabetes' is sometimes used to describe elevated blood glucose levels (hyperglycaemia) which do not reach the threshold to be classed as diabetes. Prediabetes could also be referred to as impaired fasting glucose/glycaemia (if the test is based on a fasting blood glucose sample), or impaired glucose tolerance (if the test is based on an oral glucose tolerance test). Whereas not all countries recognise the clinical term 'prediabetes', it can be useful in conversations between clinicians and patients to explain increased diabetes risk.

As dental clinicians, when we examine a patient with diabetes, we typically ask for an indication of their level of glycaemic control. Patients may report that it is 'good', or 'poor', or might say 'it varies', or 'it could be better'. Many patients can quote their most recent blood glucose values, but it is sometimes confusing as to whether these are plasma glucose values or HbA1c values. The measurement of HbA1c is routine in medical practice as part of the long-term evaluation of diabetes control, as it indicates how much haemoglobin in the blood has become glycated (ie, chemically bonded with glucose). HbA1c measurements provide an indication of blood glucose levels over the previous three months, as this is the life span of erythrocytes. Whereas historically, HbA1c was reported as a percentage (ie, the percentage of haemoglobin that has been bound by glucose), in recent years, the UK has switched to reporting HbA1c in millimoles per mole (mmol/mol) (for example, HbA1c 7% = 53 mmol/mol, HbA1c 8% = 64 mmol/mol), and conversion charts and calculators are available online. It is important that dental clinicians are familiar with the different measurement units for plasma glucose levels (mmol/l) and HbA1c (mmol/mol) as patients may report either during the discussion about their diabetes control. The diagnostic threshold for diabetes using HbA1c (non-fasting) is 48 mmol/mol (6.5%).[4]

Type 1 and Type 2 diabetes

Type 1 and type 2 are the principal categories of diabetes. Type 1 diabetes (historically referred to as insulin-dependent diabetes mellitus) results from insulin deficiency due to autoimmune destruction of the β-cells of the islets of Langerhans in the pancreas. Insulin deficiency leads to an inability to control blood glucose levels, and hyperglycaemia develops. Type 1 diabetes is believed to result from a combination of genetic predisposition and an environmental trigger (most probably, infection with an enterovirus). Type 1 diabetes tends to develop mainly in childhood, adolescence or in young adults and accounts for 5–10% of all cases of diabetes.

Type 2 diabetes (historically referred to as non-insulin-dependent diabetes mellitus) accounts for around 90% of cases of diabetes, and is caused by impaired insulin secretion and increased insulin resistance (ie, less insulin is produced, plus body cells are increasingly resistant to the effects of insulin, leading to hyperglycaemia because insulin signals body cells to take in glucose from the blood). The incidence of type 2 diabetes increases with age, with most cases being diagnosed after the age of 40, though there is an increase in younger adults and children developing type 2 diabetes. It is typically associated with lifestyle factors such as overweight/obesity and lack of exercise.

Prevalence of diabetes is increasing. In 2017, the International Diabetes Federation stated that 425 million people worldwide (8.8% of adults 20–79 years old) have diabetes, and this is predicted to rise to 629 million by 2045.[5] In the UK, there are 3.7 million people with diabetes (either type 1 or type 2) and a further one million with undiagnosed type 2 diabetes.[6] The proportion of individuals in the UK with elevated HbA1c (but which has not yet reached the threshold for diagnosis of diabetes) is also increasing; 35.3% of adults in 2011 had HbA1c values in the range 39–46 mmol/mol (5.7–6.4%) compared with 11.6% in 2003, indicating that large changes can occur at the population level within a relatively short period of time, raising concerns about the potential for future increases in diabetes prevalence.[7]

Treatment of diabetes

The aim of diabetes treatment is to reduce the risk of microvascular and macrovascular complications by controlling blood glucose, with maintenance of HbA1c below a target value. This is specific to each individual patient, and ideally will be agreed between the person and their diabetes care team as part of their overall diabetes management. In broad terms, HbA1c values <53 mmol/mol (<7.0%) would usually indicate good control. In a non-diabetic person, HbA1c is typically around 37 mmol/mol (5.5%). Reductions in HbA1c are highly relevant, because it has been shown that each 1% reduction in HbA1c (approximately 11 mmol/mol) is associated with measureable reductions in diabetes complications (eg, 21% reduction in diabetes-related deaths, 14% reduction in myocardial infarction, and 37% reduction in microvascular complications of diabetes).[8]

Diabetes treatment requires a life-long management approach. Treatment of type 1 diabetes involves careful planning of the diet, physical activity, insulin injections and self-monitoring of blood glucose levels. Treatment of type 2 diabetes involves weight loss, exercise, diet control, self-monitoring, smoking cessation, oral hypoglycaemic drugs (such as metformin) and, in some cases, insulin injections. The precise treatment strategy is tailored to the clinical situation, with the overall aim being to reduce hyperglycaemia. Compliance is a key factor affecting treatment success.

The bidirectional relationship between periodontitis and diabetes

Periodontitis is a chronic inflammatory disease that is initiated by the accumulation of dental plaque biofilm, within which microbial dysbiosis leads to a chronic, non-resolving and destructive inflammatory response. The tissue destruction that we recognise clinically as periodontitis (ie, breakdown of periodontal ligament, pocketing, and alveolar bone resorption) is primarily caused by the host inflammatory response to the bacterial challenge presented by the biofilm. Treatment of periodontitis involves professional care to reduce the bacterial challenge (oral hygiene instruction and root surface debridement), together with patient education, motivation and empowerment to optimise oral hygiene and reduce or eliminate risk factors such as smoking. Similar to diabetes, the treatment approach for periodontitis requires a life-long strategy that is tailored to the clinical situation,

with a focus on behaviour change, patient self-care, and regular professional monitoring and support. Again, similar to diabetes, compliance is a key factor for treatment success.

The risk of periodontitis is increased 2–3 times in people with diabetes compared to individuals without,[9] and the level of glycaemic control is key in determining risk.[10] Similar to the other complications of diabetes, the risk for periodontitis increases with poorer glycaemic control.[11,12] The majority of the research on periodontitis and diabetes has focused on type 2 diabetes (possibly because these diseases tend to present mainly in middle-aged adults), but type 1 diabetes has also been associated with increased periodontal destruction in children and teenagers.[13]

The pathogenic processes that link the two diseases are the focus of much research, and it is likely that upregulated inflammation arising from each condition adversely affects the other. Diabetes increases the risk for periodontitis by contributing to increased inflammation in the periodontal tissues. For example, in diabetes, there is increased deposition of advanced glycation end-products (AGEs) in the periodontal tissues, and interactions between AGEs and their receptor (RAGE, the receptor for AGEs, found particularly on macrophages) lead to activation of local immune and inflammatory responses.[14] These upregulated responses result in increased secretion of cytokines such as interleukin-1β (IL-1β), tumour necrosis factor-α (TNF-α), and IL-6, increased oxidative stress, and disruption of the receptor activator of NF-κB ligand/osteoprotegerin (RANKL/OPG) axis to favour bone resorption.[15,16] All of these factors result in local tissue damage, increased breakdown of the periodontal connective tissues and resorption of alveolar bone, thus exacerbation of periodontitis. Adiposity and pro-inflammatory adipokines (cytokines secreted by adipose tissue) further contribute to the pro-inflammatory environment.[16] It has also been shown that individuals with periodontitis and diabetes have elevated levels of circulating TNF-α, C-reactive protein (CRP) and markers of oxidative stress, with reductions in the levels of these mediators following periodontal treatment.[15]

When considering the relationship between the two diseases in the other direction, ie the impact of periodontitis on diabetes, the postulated mechanism linking the diseases is that periodontal bacteria and their products, together with inflammatory cytokines and other mediators produced locally in the inflamed periodontal tissues, enter the circulation and contribute to upregulated systemic inflammation. This leads to impaired insulin signalling and insulin resistance, thus exacerbation of diabetes. Increased HbA1c levels, in turn, contribute to increased risk of diabetes complications (including periodontitis), creating a two-way, bidirectional relationship between the diseases.[15] The effects of periodontitis on glycaemic control and diabetes risk were evaluated in a systematic review and meta-analysis of the epidemiologic evidence of the effect of periodontitis on diabetes,[17] the main findings of which are presented in Box 1.

Box 1 The effects of periodontitis on glycaemic control and diabetes risk. Data in this box are taken from Graziani *et al.*, *J Clin Periodontol* 2018; 45: 167–187[17]

In people who do not have diabetes:

- Periodontitis is associated with higher HbA1c, fasting blood glucose, and prevalence of prediabetes compared to individuals who are periodontally healthy
- The presence of severe periodontitis is associated with a statistically significant higher risk of developing diabetes (adjusted hazard ratio range 1.19-1.33, indicating a 19-33% increased risk), compared to people who are periodontally healthy

In people with type 2 diabetes:

- Periodontitis is associated with higher HbA1c levels, though the evidence to support this is not as robust as that observed in people who do not have diabetes
- Periodontitis is associated with significantly worse diabetes-related complications

In people with type 1 diabetes:

- Periodontitis is associated with higher prevalence of diabetes-related complications; but there is not sufficient evidence to assess the impact of periodontitis on glycaemic control in type 1 diabetes

The impact of periodontal treatment on diabetes

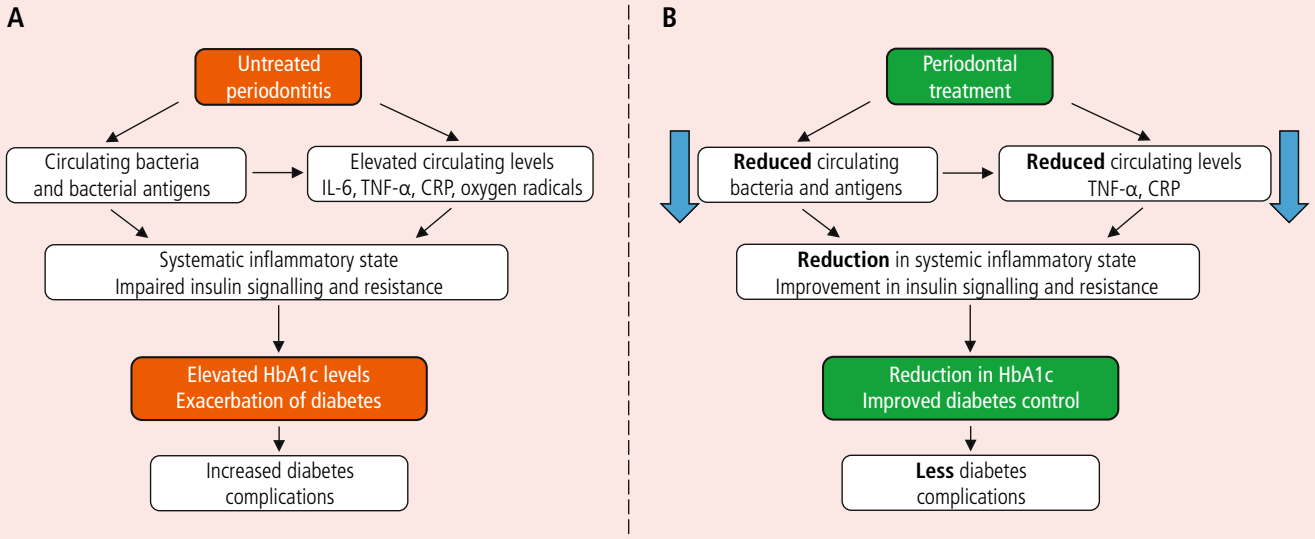
A large number of studies have been conducted over the last 2–3 decades that investigated the impact of periodontal treatment on glycaemic control in people with diabetes. The findings of these studies (many of which were conducted as randomised controlled trials, RCTs) have generally been consistent in reporting reductions in HbA1c following periodontal therapy. Two Cochrane reviews have been published on this topic, in 2010 and 2015, with both reporting statistically significant reductions in HbA1c of approximately 3–4 mmol/mol (roughly 0.3-0.4%) in the short term (3–4 months) following periodontal treatment.[18,19] More recently, in a meta-analysis of RCTs conducted since 2013, it was also reported that non-surgical periodontal treatment resulted in statistically significant reductions in HbA1c at three months post-treatment of about 4 mmol/mol (0.40%), with a range of 3–7 mmol/mol (0.27–0.65%), while at six months, the estimated reduction was lower.[20]

Periodontal treatment (professionally delivered root surface debridement and optimised oral hygiene) reduces the bacterial load in the subgingival environment, and this, in turn, results in reduced periodontal inflammation. The reduction of the subgingival bacterial load also leads to reduced levels of circulating bacteria and bacterial products. Furthermore, reduced systemic levels of pro-inflammatory cytokines and mediators (such as TNF-α and CRP) have been reported following periodontal therapy.[21,22] The precise mechanisms that lead to reductions in HbA1c and improved glycaemic control following periodontal treatment in people with diabetes are not completely clear, but are presumed to arise from the combined effects of reduced systemic inflammation and reduced bacterial challenge systemically, leading to improvements in insulin resistance and insulin signalling.[15] Given the multiple aetiological factors that contribute to hyperglycaemia, reductions in HbA1c that can be derived from any therapy (including periodontal treatment) are of benefit. Figure 1 presents a summary of the potential mechanisms linking periodontitis and diabetes, and the impact of periodontal therapy on reducing HbA1c (adapted from Polak & Shapira, 2018 [15]).

Implications for the dental team

A full medical history should be recorded for all patients as part of routine dental care, and for those with diabetes, it is important to ask about their usual treatment and their level of glycaemic control. If they self-monitor their

Fig. 1 Potential mechanisms linking periodontitis and diabetes, and the impact of periodontal therapy on diabetes control. Adapted with permission from Polak D, Shapira L, *J Clin Periodontol* 2018; 45: 150–166. Copyright John Wiley & Sons A/S.[15]
A: In untreated periodontitis, bacteria and bacterial antigens together with pro-inflammatory mediators and cytokines enter the circulation and contribute to an upregulated systemic inflammatory state. This results in impaired insulin signalling and increased insulin resistance, leading to elevated HbA1c levels and increased diabetes complications.
B: Following periodontal therapy and reductions in periodontal inflammation, there are reduced levels of circulating bacteria and antigens, and reduced circulating levels of cytokines and inflammatory mediators. This results in a reduction in the systemic inflammatory state, leading to improved insulin signalling and reduced (improved) insulin resistance. In turn, there is a reduction in HbA1c, improved diabetes control and less diabetes complications.
Key: CRP, C-reactive protein; HbA1c, glycated haemoglobin; IL-6, interleukin-6; TNF-α, tumour necrosis factor-α



blood glucose levels, it is useful to review their record book, and the dental clinician should be familiar with the units of measurements and their meaning. When patients with diabetes (particularly if there is a history of hypoglycaemia) attend for dental treatment, it is important to check that they have had their usual medications and meals, and it generally makes sense to see them early in the morning session. Patients who are using insulin may be more likely to experience hypoglycaemia, and it is helpful to ask whether they get any warning symptoms and whether they carry any glucose with them. Symptoms of hypoglycaemia can develop rapidly, and these can include trembling, sweating, anxiety, hunger, headache, confusion, slurred speech, aggression, seizures and unconsciousness. If hypoglycaemia is suspected in the dental surgery, then it should be treated as such (it may not be feasible to perform a finger-prick glucose test to confirm the hypoglycaemia in these situations). For conscious patients, glucose should be given orally, for example, in the form of dextrose tablets, sugar lumps, a drink containing 2–4 teaspoons of sugar, or glucose gel squeezed into the mouth. If the patient is unconscious, then they should be given 1 mg glucagon intramuscularly (which raises blood glucose by stimulating breakdown of stored glycogen), and medical help may need to be sought. It can take 5–15 minutes for glucagon to be effective, and the patient's airway must be protected throughout.[23]

In addition to periodontitis, a number of other oral conditions may also be associated with diabetes. These include salivary dysfunction, xerostomia, and oral mucosal diseases (such as candida infections, lichen planus and recurrent oral ulceration).[24] Medications may also contribute to dry mouth, and patients with diabetes may be taking medications such as calcium channel blockers including amlodipine and nifedipine, which can result in overgrowth of the gingival tissues, particularly if oral hygiene is poor.[25] It is important, therefore, that the medical and medication histories are obtained and regularly updated in people with diabetes.

Recently, the classification of periodontal diseases and conditions has been updated, following an international workshop that was organised jointly by the European Federation of Periodontology (EFP) and the American Academy of Periodontology (AAP),[26] and a guide for implementation of the new classification into UK general dental practice has been prepared by the British Society of Periodontology (BSP).[27] The new system stages and grades periodontitis according to extent, severity and risk. With respect to periodontitis and diabetes, the workshop concluded that although 'diabetes-associated periodontitis' should not be regarded as a distinct diagnosis, diabetes should be recognised as an important modifying factor and included in a clinical diagnosis of periodontitis as a descriptor.[28] The workshop participants considered that whereas there are no specific phenotypic features that are unique to periodontitis in patients with diabetes, the level of glycaemic control in diabetes should be used to influence the grading of periodontitis, and thus incorporate an assessment of risk into the diagnosis. It is important, therefore, that dental clinicians include diabetes as a modifying factor into the written periodontal diagnosis, and include glycaemic control in the disease grading; this will help the dental team to consider the wider general health of their patients as they formulate their diagnosis and treatment plan.

A call for multidisciplinary care in the context of periodontitis and diabetes

Periodontitis and diabetes are both prevalent diseases that adversely impact each other.

Table 1 Selected guidance and recommendations for the management of patients with periodontitis and diabetes

Author, year	Name of document	Target professionals	Summary of recommendations
IDF, 2009[47]	Guideline on Oral Health for People with Diabetes	Medical	To enquire annually regarding oral self-care and symptoms of periodontitis; inform patients about the links between periodontitis and diabetes; and advise them to see a dentist regularly.
EFP, 2012[30]	Manifesto: Periodontitis and General Health	Medical and dental	Inform patients regarding the links; advise regular periodontal monitoring; recommends dental and medical collaboration, particularly when diabetes is suspected.
EFP/AAP, 2013[31]	Consensus Report and Guidelines: Diabetes and Periodontal Disease	Medical and dental	Medical professionals: inform patients with diabetes about the links; advise to go to see a dentist regularly; newly diagnosed patients should have a periodontal assessment. Dental professionals: inform patients regarding the links; advise regular periodontal monitoring; all newly diagnosed patients with diabetes should receive periodontal assessment; recommends liaising with medical doctor when there is suspected diabetes, and potentially performing a chair-side HbA1c test.
BSP, 2016[48]	The Good Practitioner's Guide to Periodontology (3rd version)	Dental	Inform patients regarding the links and enquire about HbA1c levels; consider liaising with medical doctor regarding HbA1c levels; and liaise with the doctor when there is suspected diabetes.
BSP, 2017[36]	Diabetes and Gum Disease Campaign (part of the 2017 BSP Gum Health Awareness Day)	Medical	Inform patients with diabetes about the links; advise them to see their dental professional for assessment.
UK DoH, 2017[49]	Delivering Better Oral Health: an Evidence-Based Toolkit for Prevention (3rd edition)	Dental	Inform patients regarding the links and enquire regarding HbA1c levels; consider liaising with the medical doctor regarding HbA1c levels using a provided template letter.
EFP/IDF, 2018[32]	Consensus Report & Guidelines on Periodontal Diseases and Diabetes	Medical and dental	Medical professionals: enquire regarding symptoms of periodontitis; inform patients about the links; refer newly diagnosed patients for periodontal assessment; advise to see a dentist regularly; and collaborate with the dentist. Dental professionals: inform patients regarding links; perform regular periodontal monitoring; enquire regarding HbA1c levels; liaise with the medical doctor and consider assessing risk for diabetes in patients with suspected diabetes (for example, using a validated screening questionnaire).

Key: AAP, American Academy of Periodontology; BSP, British Society of Periodontology; DoH, Department of Health; EFP, European Federation of Periodontology; HbA1c, glycated haemoglobin; IDF, International Diabetes Federation.

Treatment of periodontitis in patients with diabetes has been shown to reduce HbA1c by 3–4 mmol/mol (0.3–0.4%) after 3-4 months, a clinical impact equivalent to adding a second line pharmacological regime in the management of diabetes.[18–20] Such reductions in HbA1c are clinically relevant, as any reduction in HbA1c equates to reduced risk of diabetes complications.[8] Importantly, periodontal treatment is a reasonably straightforward clinical intervention that has clear benefits (if performed thoroughly), and one that does not involve the need to take further medications.

While dental professionals have been aware of the links between periodontitis and diabetes for a number of years, we have previously reported that medical healthcare professionals and patients with diabetes are generally less aware of the links between the two diseases.[29] In that research, we identified that, among medical colleagues and patients, there is a lack of familiarity about the links between periodontitis and diabetes, and also a sense that it is impossible for anything to be done for patient benefit given the differing systems in which medical and dental healthcare professionals work. On the other hand, the patients with diabetes wanted all their healthcare professionals to give them consistent messages on the importance of oral health in diabetes, and help them access dental care as needed.[29] The concept of 'putting the mouth back into the body' has emerged in recent years to indicate an increased awareness of the importance of oral health as a key component of overall general health.

A number of professional and scientific organisations have produced recommendations and guidelines to improve multidisciplinary care and interprofessional working in the context of diabetes and periodontitis, and some of these are summarised in Table 1. In 2012, the EFP published their manifesto on periodontitis and general health, calling upon 'all dental and health professionals to act in the prevention, early diagnosis, and effective treatment of periodontal disease in order to combat the devastating oral and general health effects for the individual and society'.[30] This manifesto was published following an international Workshop on Periodontology (held in late 2012, with publications being produced in early 2013), in which the EFP and the AAP reviewed the evidence linking periodontitis to a number of systemic diseases including diabetes.[31] The workshop produced guidance for medical and dental practitioners on the management of patients with diabetes and periodontitis, as well as information for the patients themselves. More recently (2017), the EFP and the International Diabetes Federation (IDF) held a joint workshop on diabetes and periodontitis, and the proceedings were published simultaneously as identical papers in both a dental journal (*Journal of Clinical Periodontology*) and a medical journal (*Diabetes Research & Clinical Practice*) in order to improve awareness of the links between the diseases in both professional groups.[32,33] The publications included guidelines for dental professionals, medical professionals, and patients (whether being seen in the context of the medical practice or the dental practice). The guidelines were subsequently used as the basis for a comprehensive series

of recommendation documents, published by the EFP, for the oral healthcare team, patients and the public, medical professionals and pharmacists, policymakers, and universities and research centres, that are freely available to download from the EFP website.[34]

A criticism that can be levelled at most of the workshops and guidance documents presented in Table 1 is that they were primarily produced by periodontal specialists and academics, and did not usually include general dental or medical practitioners, or patients, in the working groups that produced the recommendation documents. Furthermore, there is a need to formally evaluate the benefits of such guidance documents to the relevant stakeholders, as if guidance is not perceived as being feasible or acceptable, then this may affect its uptake and implementation of any recommendations. The challenges of incorporating recommendations into routine clinical practice have been highlighted in the literature, particularly for busy clinicians.[35] Nonetheless, summarised key themes from the various guidance documents are:

- Medical and dental healthcare professionals should be aware of the bidirectional relationship between periodontitis and diabetes, and should communicate this information to patients;
- Medical professionals should ask patients with diabetes about their oral health and symptoms of periodontitis, should recommend visiting a dental professional for assessment, and consider collaborating with the dental team;
- Dental professionals should perform regular periodontal monitoring for patients with diabetes, should ask about glycaemic control (eg, HbA1c levels), and consider collaborating with the medical team;
- Dental professionals could consider assessing risk of diabetes when suspected (using a validated risk assessment tool, see below) and liaising with the medical doctor when there is evidence of increased diabetes risk.

Informing patients about the links between periodontitis and diabetes can be aided by the use of printed information or leaflets that the patient can take away with them after the dental appointment (or that the patient can access online). A number of different patient information documents have been produced that can be downloaded, such as those from the EFP[34] and the BSP.[36] Furthermore, the UK Diabetes Research & Wellness Foundation (www.drwf.org.uk) produces a range of very useful leaflets on diabetes and related health topics (including periodontal disease), which are available as pdf documents to download from their website. These are also available as printed leaflets that can be requested to be sent to the practice that can then be given to patients.[37] The DRWF leaflets are also available as audio files to play direct from the website.

The practicalities of improving collaboration between the dental and medical professions will vary according to the healthcare system the clinician is operating in. We have recently identified that while dental professionals in the UK frequently inform patients with diabetes about the links between diabetes and periodontitis, and consider the implications of the links in their management strategies, they rarely contact the patient's medical doctor.[38] This may be a manifestation of the perceived structural and systemic divisions that exist between the two professions as well as a lack of clear referral and communication pathways.[29] Key messages for dental professionals for management of patients with diabetes and periodontitis are presented in Box 2.

Despite the published recommendations for interprofessionalism in the context of periodontitis and diabetes (Table 1), the implementation of models of collaborative practice that cross dental and medical professional boundaries is rare, and work is required to improve this situation. An exemplar in this regard has recently been reported in the USA, in which multidisciplinary diabetes care has been delivered that included periodontal screening and treatment.[39] Patients with diabetes attended for a comprehensive appointment that involved assessment by a number of clinicians, including an endocrinologist, a clinical pharmacist, a cardiology technician as well as a dental hygienist who performed periodontal screening. The patients were discussed by all the team members (medical and dental) in a weekly multi-disciplinary team (MDT) meeting to plan the best treatment strategy. A novel 'balanced health scorecard' that displays the clinical status of 13 diabetes-relevant health domains (including periodontal disease) was also introduced (the Diabetes Cross-Disciplinary Index, DXDI©) as a means to promote communication between clinicians and with patients, and to help prioritise treatment needs. Such a model could be adapted to healthcare systems in different geographic locations, and does not necessarily require all the clinicians to be based in one centre, provided that there is a means to securely share real-time clinical data from the various health domains.

A pilot study of diabetes screening in dental patients in various clinical settings in the UK (general dental practice, a dental hospital clinic, and a dental school outreach clinic) has previously been reported.[40] The dental patients were screened for risk of diabetes (according to a diabetes risk questionnaire and measurement of body mass index, BMI), and those who were identified as being at moderate or high risk were recommended to visit their medical doctor for further investigations. Dental clinicians were trained in the use of the screening tool and BMI measurement, and both the clinicians and the patients welcomed the opportunity to be involved in this process. However, the additional time required was

Box 2 Key messages for dental healthcare professionals in relation to diabetes and periodontitis

Dental healthcare professionals:

- Should be aware of the links between periodontitis and diabetes
- Should inform patients about the links, highlighting that there is an established bidirectional relationship between the two diseases
- Should regularly update the medical and medication history of patients with diabetes and ask about the level of diabetes control
- Should be familiar with the measurement units for plasma glucose and glycated haemoglobin (HbA1c), and have broad understanding of how these relate to the level of glycaemic control
- Should perform regular periodontal monitoring for patients with diabetes and provide appropriate preventive care and periodontal treatment as necessary
- Could consider assessing risk of diabetes when suspected (for example, using a validated questionnaire such as the Diabetes UK Diabetes Risk Score) and liaising with the medical doctor when there is evidence of increased diabetes risk (i.e., a moderate or high risk as identified by the Diabetes Risk Score). The Diabetes Risk Score can be downloaded from the Diabetes UK website (www.diabetes.org.uk), after completing the online enquiry form,[41] or accessed as an online questionnaire.[45]

substantial, adding approximately 20 minutes to the length of the dental appointment, which would not be practical in most dental practice settings. On the other hand, this research did demonstrate the expanded role that the dental team can play in screening dental patients for risk of diabetes.

For those dental clinicians who wish to perform diabetes risk screening, we recommend using the Diabetes UK Diabetes Risk Score (launched in 2010), also known as the Leicester Self-Assessment tool.[41] This is an evidence-based, validated tool that was developed as a collaboration between Diabetes UK, the University of Leicester and University Hospitals of Leicester NHS Trust,[42,43] and which is endorsed by NICE (the National Institute for Health and Care Excellence) in their public health guideline 38 document (NICE PH38) 'Type 2 diabetes: prevention in people at high risk'.[44] Indeed, NICE suggested a number of possible healthcare venues where the tool could be used including community pharmacies, dental surgeries, NHS walk-in centres and opticians. The tool consists of seven questions related to age, gender, ethnicity, family history, waist measurement, BMI and blood pressure history, and indicates whether a person is at low, increased, moderate or high risk of developing type 2 diabetes. The tool is available to use free of charge by healthcare professionals working in the NHS or private healthcare (provided that they do not intend to make monetary gain when using it). Any healthcare professional can download the one page tool from the Diabetes UK website (www.diabetes.org.uk), after completing the online enquiry form.[41] The Diabetes Risk Score is also available as an online questionnaire under the descriptor 'Type 2 Diabetes Know Your Risk' for anyone to use via the web, also available at the Diabetes UK website.[45]

For interactions between healthcare professionals to be meaningful, all parties should perceive a benefit. The use of the Diabetes Risk Score by dental clinicians could help to improve communication with medical colleagues in relation to diabetes and periodontitis. In a validation study of the Diabetes Risk Score it was found that, of those identified as being at high risk of diabetes, 89% will go on to be diagnosed with type 2 diabetes in the next 10 years.[46] Thus, if a dental clinician suspects that a patient may have undiagnosed diabetes (for example, because of presence of severe periodontitis coupled with factors such as a positive family history of diabetes and overweight/obesity) and decides to use the Diabetes Risk Score, and finds that the patient is at moderate or high risk, then this would form the basis for very valuable communication between the dental and medical clinicians. The completed Diabetes Risk Score could be given to the patient to take to an appointment with their medical doctor, together with a letter from the dentist to explain the background to the case.

Conclusions

Diabetes increases the risk for periodontitis, and the level of glycaemic control is key in determining the level of risk. A bidirectional relationship exists between the two diseases, with upregulated inflammation arising from each condition having adverse effects on the other. In people who do not have diabetes, periodontitis is associated with higher HbA1c and fasting blood glucose compared to those who do not have periodontitis, and presence of severe periodontitis is associated with a statistically significant higher risk of developing diabetes compared to people who are periodontally healthy. In people with type 2 diabetes, periodontitis is associated with higher HbA1c levels, and significantly worse diabetes-related complications compared to those who do not have periodontitis. Non-surgical periodontal treatment leads to improved glycaemic control and clinically relevant reductions in HbA1c of around 3–4 mmol/mol (0.3–0.4%) at 3–4 months following treatment. Periodontal screening and treatment of periodontitis is fundamentally important in people with diabetes, and both dental and medical healthcare professionals should inform patients about the links between the two diseases and work towards improved collaboration and interprofessional working. The dental team has an important role to play in the management of patients with diabetes. This can include screening patients in relation to diabetes risk (eg, using the Diabetes UK Diabetes Risk Score), collaborating with medical colleagues regarding periodontitis and diabetes when indicated, and treating periodontitis with the aim of both improving periodontal health and also contributing to improved glycaemic control in patients with diabetes.

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