Does the dentist have a role in identifying patients with undiagnosed diabetes mellitus?

Précis
This paper provides a literature review of the role of the dentist in screening patients for undiagnosed diabetes in the dental clinic. It highlights both dentist and patient attitudes towards such screening methods.

Abstract

Statement of the problem: Diabetes has become an epidemic and the incidence of undiagnosed diabetes is growing at an alarming rate. Diabetes is an associated risk factor for chronic periodontitis and has several other oral symptoms including dry mouth and oral infection. Expanding the role of the dentist may prove to be an efficient method of early detection and management of diabetes.

Purpose of the study: The aim of this paper is to critically analyse the literature and determine whether screening for undiagnosed diabetes mellitus is within the dentist’s scope of practice.

Materials and methods: A PubMed/Google Scholar/Google literature search was conducted of papers published in the English language in the years 1980-2013. Over 140 articles were examined. Reference lists of key articles were also sourced and analysed. The most pertinent articles are presented in this review.

Results: Screening for diabetes mellitus in the dental office should only be carried out for high-risk patients in order for such screenings to be cost-effective.

Conclusions: Dentists have an ethical obligation and a duty of care to protect the well-being of their patients. A screening procedure to detect a serious underlying, undiagnosed systemic condition does not cause any harm to the patient and is in the patient’s best interests.

Introduction
Diabetes mellitus is a syndrome of abnormal carbohydrate, fat and protein metabolism that is caused by an absolute or relative lack of insulin. Type 1 diabetes usually develops in childhood and has a genetic, viral or autoimmune aetiology. Type 2 diabetes has a multifactorial aetiology with a strong genetic component and the condition can be prevented by simple lifestyle education.
Type 2 diabetes accounts for 90% of diabetes worldwide and is characterised by insulin resistance. Diabetes mellitus is now an epidemic with 366 million people affected globally. This number is projected to rise to 552 million in 2030. It is estimated that 183 million people with diabetes are undiagnosed. Diabetes is reported to have been responsible for 4.6 million deaths worldwide in 2011. The World Health Organisation (WHO) has projected that diabetes will be the seventh leading cause of death in the year 2030. Complications of undiagnosed or poorly controlled diabetes include retinopathy, neuropathy, nephropathy, peripheral vascular disease, coronary heart disease, gangrene and periodontitis. Early detection of pre-diabetes may stop the transition to established diabetes mellitus and, subsequently, life-threatening complications may be avoided. In the United States (US), up to 65% of people attend their dentist every year. In Europe, 57% of people visit their dentist every year and 54% of Irish people attend their dentist annually. This puts the dentist in a favourable position to screen for undiagnosed diabetes and to make a referral for further investigations to the patient’s physician.

This literature review aims to determine whether the dentist has a role in screening patients for undiagnosed diabetes in the dental clinic.

**Oral features of diabetes mellitus**

Apart from obvious signs and symptoms of hyperglycaemia such as sudden unexplained weight loss, acanthosis nigrans marker, visual disturbances, polyuria (increased urination), polydipsia (increased thirst), polyphagia (increased appetite) and lethargy, there are various oral features that can be detected during a routine dental examination, which may alert the dentist to an undiagnosed systemic condition. The poorer the glycaemic control, the more evident the oral manifestations of diabetes mellitus are to the clinician. However, these oral features are not exclusive to diabetes and other causes should be excluded.

The most common oral complications of diabetes are gingivitis and periodontal disease. Periodontal disease was described by Loe as the sixth complication of diabetes and he concluded that adults were three times more likely to have periodontitis if they suffered from diabetes. Periodontitis has also been reported in children with poorly controlled diabetes and research shows that individuals with diabetes have higher plaque levels than non-diabetics. Initially, individuals with diabetes develop gingivitis and the transition to, and progression of, periodontitis is related to the rate at which the glycaemic control worsens. Salivary hyperglycaemia and an elevated glucose content of the gingival crevicular fluid are thought to provide an added supply of nutrients to periodontal bacteria. It has also been established that periodontal disease and diabetes share a bidirectional relationship, where poor glycaemic control impacts on the outcome of periodontal treatment and periodontitis negatively affects the patient’s glycaemic control. Advanced glycation end products (AGEs) are formed under hyperglycaemic conditions due to non enzyme-based reactions involving the metabolism of lipids and proteins, and the build up of AGEs in the gingival tissues interferes with collagen formation. The level of receptor for advanced glycation end products (RAGE) is elevated in the gingival tissue of people with diabetes. Expression of RAGE on the cell membranes of gingival epithelial cells and fibroblasts enables signalling through RAGE, which releases harmful free radicals and pro-inflammatory components that exacerbate periodontal disease and diabetes mellitus.

Patients with diabetes also have a greater susceptibility to infections and subsequently have a poor response to healing due to impaired neutrophil and fibroblast function. Polypuria due to osmotic diuresis leads to dehydration and therefore reduced production and altered consistency of saliva resulting in xerostomia and dysgeusia (altered taste). Xerostomia may also be a side effect of diabetic medication. Chronic periodontitis is characterised by clinical attachment loss resulting in gingival recession. Gingival recession, along with salivary hyperglycaemia and salivary hypofunction predispose to an increased incidence of root caries in diabetic patients. The evidence linking coronal caries to diabetes, however, is inconsistent. Diabetic individuals yield higher streptococci count in their oral flora, suffer from salivary dysfunction and have reduced salivary buffering capacity that may contribute to increased dental caries. Lalla and colleagues carried out a study on 342 children and found that the caries experience was the same between children with diabetes and non-diabetic children. *Candida albicans* is an opportunistic fungal pathogen that is commonly present in the mouth and can become pathogenic in the presence of predisposing factors. In people with diabetes, impaired neutrophil function, xerostomia and salivary hyperglycaemia predispose to oral candidial infections, including oral candidiasis, angular cheilitis, denture stomatitis and median rhomboid glossitis.

Longstanding hyperglycaemia can cause neuropathy and dehydration, which may manifest as a burning sensation in the oral cavity. This burning sensation can be one of the presenting symptoms of chronic hyperglycaemia and is frequently overlooked during clinical examination. A burning sensation in the mouth has been found to be more prevalent in patients with undiagnosed type 2 diabetes. Epidemiological data from Hungary suggests that patients with diabetes may be at an increased risk of developing potentially malignant lesions in the oral cavity, although this is the only study to have shown this. However, the accuracy of using fasting blood glucose for diabetes testing may be less than satisfactory. Also, there was a high percentage of current and recent smokers in the group. Oral hypoglycaemic drugs are known to cause lichenoid drug eruptions, which may be indistinguishable from the clinical appearance of oral lichen planus (OLP). Coated tongue and erythema migrans (geographic tongue) have been noted in patients with diabetes mellitus. Recurrent oral infections such as recurrent ulceration, recurrent episodes of herpes simplex infections and recurrent periodontal abscesses are all reported in diabetes mellitus, especially in marginally controlled cases. Halitosis, specifically in the form of a distinct ketonic breath, has been observed in patients with...
uncontrolled diabetes. Table 1 shows oral features that have been reported to be associated with diabetes mellitus. Asymptomatic bilateral enlargement of the parotid glands is referred to as sialosis and is seen in approximately 24% of individuals with diabetes mellitus. Infiltration of the parenchyma with adipose tissue leads to the enlargement of the parotid glands.

### Dental office screening models for diabetes mellitus

Dental office screening for diabetes mellitus using gingival crevicular blood is a relatively new concept and only a few studies have been carried out, with no randomised controlled trials available to date. The advantages of utilising blood collected following periodontal probing are two-fold. Firstly, the patient’s attitude towards this form of screening is more tolerated and viewed as less invasive than alternative screening methods such as finger prick testing. Secondly, the majority of state dental boards in the US do not approve alternative screening methods such as finger prick testing. Studies have proven that glucose levels of blood obtained from the gingival crevice are significantly comparable to glucose levels of blood obtained from the finger puncture method and venous blood. A small amount of blood ranging from 0.3ml to 0.6ml is enough for a measurement to be carried out with a self-monitoring device. Strauss and colleagues showed that 85% of patients were capable of producing sufficient bleeding for a measurement. Obtaining a blood sample from the gingival crevice involves isolating the most anterior tooth with a cotton roll, probing the pockets around the tooth with light pressure of no more than 20g and then placing a test strip directly into contact with the gingival crevicular blood. A reading can be processed in five seconds and the monitor can then be set aside and the periodontal screening completed.

<table>
<thead>
<tr>
<th>Table 1: Oral features associated with diabetes mellitus.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gingivitis</strong></td>
</tr>
<tr>
<td><strong>Periodontitis</strong></td>
</tr>
<tr>
<td><strong>Poor wound healing</strong></td>
</tr>
<tr>
<td><strong>Dry mouth</strong></td>
</tr>
<tr>
<td><strong>Root caries</strong></td>
</tr>
<tr>
<td><strong>Candidal infections including angular chelitis, denture stomatitis and median rhomboid glossitis</strong></td>
</tr>
<tr>
<td><strong>Halitosis</strong></td>
</tr>
</tbody>
</table>

Obtaining a blood sample from the gingival crevice involves isolating the most anterior tooth with a cotton roll, probing the pockets around the tooth with light pressure of no more than 20g and then placing a test strip directly into contact with the gingival crevicular blood. A reading can be processed in five seconds and the monitor can then be set aside and the periodontal screening completed.

There are four principal blood tests used to screen for diabetes: fasting blood glucose (FBG); oral glucose tolerance test (OGTT); random blood glucose (RBG); and glycated haemoglobin A1c (HbA1c). FBG and OGGT are not practical for dental patients as patients must be fasting for at least eight hours prior to these tests. HbA1c, which gives a measure of the level of glucose bound to haemoglobin and is a reflection of the blood glucose control over the previous three months, has recently been advocated by the American Diabetes Association as the gold standard test for screening and diagnosing diabetes. RBG (normal <7.8mmol/L) and HbA1c (normal <5.7% or <42mmol/mol) tests have been suggested for screening in the dental clinic as patients are not required to fast prior to their appointment. An RBG measurement of >7.8mmol/L and a HbA1c of >5.7% or >42mmol/mol warrant a referral to a general practitioner for further investigation.

### Table 2: Effectiveness of screening for undiagnosed diabetes in the dental clinic.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Number</th>
<th>Methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strauss and colleagues</td>
<td>2012</td>
<td>120</td>
<td>Fingerstick blood samples from 120 patients and gingival crevicular blood samples were collected on special blood collection cards and analysed for HbA1c levels in a laboratory</td>
<td>35% = pre-diabetes</td>
</tr>
<tr>
<td>Borrell and colleagues</td>
<td>2007</td>
<td>4,830</td>
<td>Using a logistic regression model with a self-reported family history of diabetes, hypertension, high cholesterol and periodontal disease.</td>
<td>27-53% = potential diabetic</td>
</tr>
<tr>
<td>Beitzer and colleagues</td>
<td>2002</td>
<td>45</td>
<td>Statistical analysis was performed by Pearson’s correlation coefficient comparing fingerstick blood and gingival crevicular blood.</td>
<td>Blood samples taken from gingiva and fingertip showed very high inpatient correlation</td>
</tr>
<tr>
<td>Li and colleagues</td>
<td>2011</td>
<td>7,545</td>
<td>Utilised Third National Health and Nutrition Examination Survey (NHANES III) (1988-1994) and a list of predictors.</td>
<td>Sensitivity of 82.4%</td>
</tr>
<tr>
<td>Lalla and colleagues</td>
<td>2011</td>
<td>601</td>
<td>1. Self-reported risk factors 2. At least four teeth are missing 3. At least 26% of pockets have a depth of more than 5mm 4. Fingerstick point of care HbA1c of 5.7% or higher</td>
<td>Blood samples from 120 patients and gingival crevicular blood.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Number</th>
<th>Methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strauss and colleagues</td>
<td>2012</td>
<td>120</td>
<td>Fingerstick blood samples from 120 patients and gingival crevicular blood samples were collected on special blood collection cards and analysed for HbA1c levels in a laboratory</td>
<td>35% = pre-diabetes</td>
</tr>
<tr>
<td>Borrell and colleagues</td>
<td>2007</td>
<td>4,830</td>
<td>Using a logistic regression model with a self-reported family history of diabetes, hypertension, high cholesterol and periodontal disease.</td>
<td>27-53% = potential diabetic</td>
</tr>
<tr>
<td>Beitzer and colleagues</td>
<td>2002</td>
<td>45</td>
<td>Statistical analysis was performed by Pearson’s correlation coefficient comparing fingerstick blood and gingival crevicular blood.</td>
<td>Blood samples taken from gingiva and fingertip showed very high inpatient correlation</td>
</tr>
<tr>
<td>Li and colleagues</td>
<td>2011</td>
<td>7,545</td>
<td>Utilised Third National Health and Nutrition Examination Survey (NHANES III) (1988-1994) and a list of predictors.</td>
<td>Sensitivity of 82.4%</td>
</tr>
<tr>
<td>Lalla and colleagues</td>
<td>2011</td>
<td>601</td>
<td>1. Self-reported risk factors 2. At least four teeth are missing 3. At least 26% of pockets have a depth of more than 5mm 4. Fingerstick point of care HbA1c of 5.7% or higher</td>
<td>Blood samples from 120 patients and gingival crevicular blood.</td>
</tr>
</tbody>
</table>
perform a screening test that yields immediate results and are less willing to have a screening test done if the samples have to be sent out to an outside laboratory.\textsuperscript{29} Chair-side point-of-care HbA1c testing has the advantage of results that are strongly correlated with laboratory results being available within five minutes, without having to be sent to a laboratory.\textsuperscript{29} Existing studies have only utilised gingival crevicular blood testing by means of a glucometer or have required samples to be sent to a laboratory on special collection cards for HbA1c analysis and as of yet no studies have investigated chair-side point-of-care HbA1c testing of gingival crevicular blood. The cost-effectiveness and simplicity of this concept means that there is a valuable opportunity to research this novel concept in the future.

The most recent evidence suggests that the screening models are effective (Table 2). The model proposed by Strauss and colleagues\textsuperscript{27} using gingival crevicular blood measured via laboratory HbA1c testing identified 55\% of patients as having pre-diabetes and 17\% as being potentially diabetic. Several studies have used the National Health and Nutrition Examination Surveys (NHANES) (1988-1994 and 2003-2004) to develop a prediction model using self-reported data to screen for undiagnosed diabetes in a dental setting.\textsuperscript{3,10,31} These studies reported varying sensitivities. The model proposed by Li and colleagues\textsuperscript{3} yielded a sensitivity of 82\%. The model proposed by Lalla and colleagues\textsuperscript{3} could predictably identify 92\% of true cases, when: at least four teeth are missing; at least 26\% of pockets have a depth of more than five millimetres; and, there is a HbA1c of 5.7\% or higher. This pilot study identified 30\% of patients as being pre-diabetic and 4\% of patients as potentially diabetic.

Screening for diabetes mellitus in the dental office should only be carried out for high-risk patients in order for such screenings to be cost-effective. The American Diabetes Association has developed criteria that classifies high-risk patients as being anyone that:

- (1) is over 45 years of age;
- (2) has a family history of diabetes;
- (3) has a BMI $\geq 26$ kg/m$^2$;
- (4) does not exercise regularly;
- (5) has hypertension;
- (6) has hyperlipidaemia;
- (7) is of a certain racial or ethnic group (African American or Hispanic); and,
- (8) has had gestational diabetes.

The greater the number of risk factors a person has, the higher the risk they have for developing diabetes. With the aid of the above criteria, clinical judgement should be used to determine which patients are high risk and are therefore eligible for screening.

The landmark study by Lalla and colleagues\textsuperscript{10} utilised multivariate regression analysis to predict the most ideal screening parameters, and identified periodontal pocket depths (PPDs), tooth loss and point of care HbA1c testing as the suggested screening parameters. Although this study yielded a potentially novel screening approach, it had some noteworthy limitations. The study used PPDs instead of clinical attachment level (CAL) to measure the periodontal status, whereas CAL is preferred according to the definition of periodontitis by the American Academy of Periodontology, and the authors did not use the American Diabetes Association criteria of self-reported risk factors to increase statistical sensitivity. The study also did not use point-of-care HbA1c gingival crevicular blood for a glucose measurement but instead used fingerstick HbA1c, which is not approved by the majority of US dental boards. It was recently reviewed in the *Journal of Evidence Based Dental Practice* and commentary illustrated that using this screening algorithm, 8\% of true diabetic cases were not identified and consequently these people would have remained unrecognised, potentially resulting in serious complications.\textsuperscript{33} However, false negatives of this nature may be overcome by subsequent screenings at future visits.\textsuperscript{5}

### Attitudes towards screening for medical conditions in a dental setting

A questionnaire-based study identified that the most critical element required for chair-side medical screening in a dental setting is acceptance by patients.\textsuperscript{29} More than 90\% of patients surveyed felt that it was important for dentists to screen for systemic diseases that they may otherwise be unaware of, and several recent studies found that diabetes screening in a dental office was well accepted by patients.\textsuperscript{15,21,28} Recent studies have also shown that the majority of dentists feel that it is important to screen for undiagnosed medical conditions in a dental setting\textsuperscript{21,34} and, moreover, dentists said they were willing to participate in such screening methods.\textsuperscript{24}

A potential barrier to such screening procedures is that patients may feel that their dentist is not adequately trained to carry out a medical screening but a questionnaire-based survey of 433 patients identified that screening of medical conditions by a dentist rather than a physician was the least important barrier.\textsuperscript{34} Studies have found that more than 90\% of dentists would refer patients to their general practitioner for further testing\textsuperscript{20,35} and almost 90\% of dentists were willing to collect saliva for diagnostics as opposed to a 55\% willingness to collect blood via fingerstick.\textsuperscript{34} It would be interesting to see in future research what dentists’ attitudes would be in terms of their willingness to carry out HbA1c gingival crevicular blood testing in the dental clinic. A major barrier is reimbursement. The current cost of a portable chair-side HbA1c machine (Bayer’s A1CNow+à SELFCHECK) is approximately $39.99 and fortunately in the United States this machine is reimbursable by the government. It is hoped that in the near future this would also be the case in Europe. This product is FDA approved, results are lab accurate, can be obtained in five minutes and only a small amount of blood is required.

In order for a screening strategy to be effective dentists must feel confident in their ability to carry out a screening efficiently. General dental practitioners (GDPs) were asked about their attitudes towards screening for diabetes in the dental clinic and the majority lacked confidence in their abilities to screen for diabetes.\textsuperscript{35} To tackle this confidence barrier, training courses on how to screen for medical conditions in a dental setting should be introduced at an undergraduate level and as part of continued professional development (CPD) programmes. It has been shown that formal
training can enhance the dentists’ confidence in assessing diabetes.\textsuperscript{36}

**Discussion**

Diabetes has become an epidemic and the incidence of diabetes is growing at an alarming rate. Expanding the role of the dentist may prove to be an efficient way of controlling this rapidly growing epidemic.

The cost-effectiveness of screening for undiagnosed diabetes in a medical setting has been well documented in the medical literature. The literature thus far concludes that screening for diabetes is only cost-effective and worthwhile in targeted high-risk groups.\textsuperscript{26,33} Studies have illustrated that screening for cardiovascular-associated events and hypertension can be carried out effectively in a dental setting. Therefore, screening for diabetes mellitus, targeted at high-risk individuals, and cardiovascular-associated events in one complete screening procedure should be considered.

Early detection of an undiagnosed systemic condition significantly improves the prognosis of the condition, improves the patient’s quality of life and lessens the complications associated with the condition.\textsuperscript{5} It must be made clear that the dentist’s role stops here. A reliable diagnosis of diabetes mellitus cannot be made by a glucometer and furthermore the dentist is not covered medico-legally to make such a diagnosis. The dentist has an obligation to refer a patient who tests positive to an appropriate medical service for formal diagnosis and management.

In 2007, the United States healthcare system spent $174 billion on diabetes mellitus and $465 billion in 2011.\textsuperscript{4} In 2011, the Irish Health Service spent approximately €4 billion on obesity and diabetes. The number of newly diagnosed cases of diabetes is increasing every year and the increases in healthcare costs are a reflection of this. Screening for undiagnosed diabetes mellitus could provide long-term healthcare savings, as less money would hopefully need to be spent on managing complications that could be avoided with early detection, referral and appropriate treatment.\textsuperscript{34}

Dentists have an ethical obligation and a duty of care to to protect the well-being of their patients. A screening procedure to detect a serious, underlying, undiagnosed systemic condition, and that does not cause any harm to the patient, is in the patient’s best interests.

Dentists are well placed to screen for systemic conditions because of the high annual attendance level and because dentists can carry out a gingival crevicular blood test. More importantly, dentists are more familiar with the mouth, and are therefore ideally placed to diagnose periodontal disease and other oral manifestations of diabetes that medical practitioners may not be as familiar with.

**Conclusion**

The recommendation of this review is to use a four-step screening approach combining:

1. The American Diabetes Association criteria for classifying high-risk patients;
2. The presence of periodontal disease defined by clinical attachment level;
3. The presence of oral features indicative of undiagnosed diabetes; and,
4. A chair-side point-of-care HbA1c gingival crevicular blood test to create the most ideal, cost-effective and user-friendly screening model.

Pending further research focused on trialling the above proposed screening model and pending approval from medical and dental councils, it is suggested that a universal clinical guideline to screen patients at dental visits for undiagnosed diabetes mellitus be developed, implemented and made a public health priority. Dentists are ideally suited to screen for signs and symptoms of undiagnosed diabetes through medical history taking and oral examination, and should refer any patients about whom they have concerns to their general medical practitioner for further testing.

Periodontitis is currently not included in the American Diabetes Association criteria for classifying high-risk patients. There may be a reasonable argument for including periodontal disease in the ADA criteria for classifying high-risk patients as recent research has confirmed the bidirectionality of periodontal disease and diabetes, and periodontal disease is the most common oral complication of undiagnosed diabetes.

Dentists certainly have an important role in identifying patients with undiagnosed diabetes mellitus and they may also play an important role in the management of this condition by aggressively treating periodontal disease, which may improve glycaemic control.\textsuperscript{35,36,37}

**References**