Diabetics’ Awareness of Oral Disorders Associated with Diabetes Mellitus

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1 Introduction

Diabetes mellitus is made up of a group of metabolic disorders characterized by inappropriate blood hyperglycaemia, due to failure of the pancreatic beta cells to produce insulin and/or inability of the body to use the insulin produced because of insulin resistance in the body cells. Diabetes mellitus is a growing problem worldwide, it affects five percent of the world's population and the number of cases is doubling every generation (King et al., 1998).

The medical professionals have been aware of diabetes mellitus and have studied it for many years, but have made little progress in halting its spread. In fact, the prevalence of diabetes mellitus has been increasing worldwide at such a rate that recently the World Health Organization (WHO) declared the disease an epidemic. Worldwide, the number of estimated cases of diabetes mellitus has increased from 30 million in 1985 to 135 million in 1995 (Smyth & Heron, 2006). Furthermore, WHO reported that by the year 2030 the number of estimated cases of diabetes mellitus is projected to increase to 366 million. In most of the world, this increase is directly attributed to a genetic predisposition to the disease and also to lifestyle changes that modern development has brought on, such as a high-sugar diet, physical inactivity, obesity, as well as other aetiological factors.

2 Global Prevalence of Diabetes Mellitus

The estimated number of the global prevalence of diabetes mellitus in the year 2000 and the projections for year 2030, as reported by the WHO Global Burden of Disease Study, in the Middle Eastern, United States of America, Canada, European, Asian and African countries are shown in Figures 1, 2, 3 and 4, respectively. Worldwide, the number of people with diabetes mellitus is expected to double between 2000 and 2030 in most of the countries shown in the Figures (1-4). The greatest increase in the number of people with diabetes by 2030 among the Middle Eastern countries will be in Egypt, as seen in Figure 1 in close proximity to 7 million diabetic cases. In the Asian countries the estimated number will be massive, about 80 million diabetic cases, in India (Figure 3) and approximately 5 million diabetic cases in Nigeria among the African countries (Figure 4). This terrifying increase in the estimated number of people with diabetes mellitus by year 2030 in these countries (Egypt, India and Nigeria) could be attributed to the increase in population growth, aging, prevalence of obesity and physical inactivity.

2.1 Global Prevalence of Diabetes Mellitus by Population Age in Developed and Developing Countries

The global prevalence of diabetes mellitus by population age in year 2000 and 2030 for the developed countries is increasing in certain age groups. It has been shown that by the year 2030 it is projected that there will be a remarkable increase in the estimated number of diabetic cases in the age group 65 years and above, reaching 58 million cases from 26 million cases in the year 2000. There is also a projected increase in the estimated number of diabetic cases from 24 to 32 million cases in the age group 45-64 years by the year 2030. However, it is projected that the estimated cases for the age group 20-44 years will remain the same (5 million cases) without a noticeable change by 2030. Whereas, in the developing countries the estimated diabetic cases for the same age group (20-44 years) are projected to increase from 30 million cases in the year 2000 to 55 million cases in the year 2030. There will also be a terrifying in-
Figure 1: Prevalence of diabetes mellitus in the Middle Eastern countries. Adapted with permission from: http://www.who.int/diabetes/facts/world_figures/en/index.html

Figure 2: Prevalence of diabetes mellitus in the U.S.A., Canada and some European countries. Adapted with permission from: http://www.who.int/diabetes/facts/world_figures/en/index.html

Figure 3: Prevalence of diabetes mellitus in some Asian countries. Adapted with permission from: http://www.who.int/diabetes/facts/world_figures/en/index.html
crease in the prevalence of diabetes mellitus in the age groups 45-60 years and 60-above years as compared to that of the developed countries for the same age groups by the year 2030. The estimated number of people with diabetes for age group 45-64 years, in the developing countries, is dramatically increased from 60 to 145 million cases and from 28 to 82 million cases for the age group 65 years and above by the year 2030 (Wild et al., 2004). The decrease in the estimated diabetic cases for years 2000 and 2030 in the age group 65-above years compared to age group 45-64 years in the developing countries can be attributed to the failure of diabetic patients to reach that age (65-above years) due to serious diabetes mellitus complications. Cardiovascular disease (coronary artery disease) as result of diabetes complications is increasing the number of deaths among people with diabetes in these developing countries, as well as increased prevalence and associated consequences of other complications of diabetes mellitus (Wild et al., 2004). The reported evidence suggests that the current and future increase of the global prevalence of diabetes mellitus in both developed and developing countries creates morbidity and mortality for millions of people worldwide (Mealey, 2000).

3 Pathophysiology of Diabetes Mellitus

3.1 Mechanism of Action of Insulin

Insulin is a hormone that regulates carbohydrate and fat metabolism in the body. Presence of glucose in the bloodstream stimulates the production of insulin by beta-cells in the Islets of Langerhans of the pancreas. Insulin binds to receptors on the target cells (in particular muscle cells, liver cells and adipose tissue) facilitating the uptake of glucose from the bloodstream into the cells. This leads to lowered blood glucose levels because glucose leaves the bloodstream and enters the cells to be utilized for energy, which acts as a negative feedback cycle causing a decrease in the production of insulin. Therefore, an increase in blood glucose level (hyperglycaemia) will result from decreased insulin production or in cases of peripheral resistance to insulin. On the other hand, an increase in insulin production will cause decrease in blood glucose level (hypoglycaemia). Insulin is the only hormone in the body that lowers blood
glucose levels while, other hormones such as glucagons, growth hormone, thyroid hormone, catecholamines (epinephrine) and glucocorticoids all increase blood glucose levels.

3.2 Pathophysiology of Type 1 Diabetes Mellitus

The cause of type 1 diabetes mellitus is an autoimmune destruction of pancreatic beta-cells in the Islets of Langerhans of the pancreas resulting in an absolute insulin deficiency. Hence, the term insulin-dependent diabetes mellitus is used because the pancreatic beta-cells no longer produce insulin making the body dependent on exogenously administered insulin. The actual reason behind the autoimmune beta-cell destruction is unknown but one theory suggests that an environmental factor such as a viral infection is the cause of this destruction (Mandrup-Poulsen, 1998). Genetics do also play a role in increasing the risk of this autoimmune condition.

3.3 Pathophysiology of Type 2 Diabetes Mellitus

There is a strong genetic influence in acquiring Type 2 diabetes mellitus, however, it is also affected by acquired factors such as obesity, advancing age and inactive lifestyle (Mandrup-Poulsen, 1998). In type 2 diabetes mellitus the beta-cells in the Islets of Langerhans of the pancreas do produce insulin, but the tissues do not utilize it because the target cells have increased resistance to insulin. This leads to persistent hyperglycemia. Glucose accumulates in the bloodstream increasing the demand for insulin production by the beta-cells, and eventually the beta-cells can no longer cope with this increased demand and undergo apoptosis.

4 Classification of Diabetes Mellitus

The American Diabetes Association characterized diabetes mellitus into two major forms of diabetes, Type 1 and Type 2. Type 1 previously termed insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes and Type 2 termed as non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. Type 1 is characterized by defects in insulin secretion, and subdivided further into Type A (immune related) and Type B (idiopathic), and Type 2 is mainly characterized by insulin resistance (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 1998).

In addition to the mentioned causes, diabetes mellitus can also be brought about by pregnancy, certain drugs, or it could occur as a result of some autoimmune diseases, genetic disorders or as a result of infection (Manfredi et al., 2004). All types of diabetes mellitus are characterized by hyperglycaemia or elevated plasma glucose level.

Type 1 affects mostly children and young adults but it can occur at any age, while type 2 commonly occurs in adults after the age of forty, but it also affects young adults due to the increase in childhood obesity (Delong & Burkhart, 2008).

4.1 Pre-diabetes Mellitus Stage

An active stage of progressive beta cell deterioration and insulin resistance is typical of pre-diabetes stage. It manifests before the development of impaired glucose tolerance and clinical diabetes. The level of blood glucose is higher than normal level but not high enough for a diagnosis of diabetes. The pre-diabetes stage usually takes years to develop into clinical diabetes mellitus. As reported by the American
Diabetes Association, about 57 million Americans are at the pre-diabetes stage in the United States of America.

4.2 Plasma Glucose Levels Associated with Pre-diabetes and Diabetes Mellitus Stages

As recommended by the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (1998), the primary methods to diagnose diabetes mellitus and monitor blood glucose levels by fasting plasma glucose test or oral glucose tolerance test or combination of both tests. In addition to the relevant classical clinical symptoms of diabetes include polyuria, polydypsia, chronic fatigue, and unexplained weight loss. Currently, glycosylated haemoglobin test is used to investigate and confirm plasma glucose level over past weeks to months.

Pre-diabetes stage is diagnosed when the fasting plasma glucose (FPG) levels reach 100-125 mg dl⁻¹ along with a corresponding impaired oral glucose tolerance test (OGTT) at a level of 140-199 mg dl⁻¹ as seen in Table 1. Clinical diabetes is diagnosed when the FPG equals or above 126 mg dl⁻¹ and the OGTT equals or above 200 mg dl⁻¹ (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus 1998).

<table>
<thead>
<tr>
<th>Plasma glucose test</th>
<th>Normal</th>
<th>Pre-diabetes</th>
<th>Diabetes mellitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting plasma glucose (FPG)</td>
<td>&lt; 100 mg/dl</td>
<td>100 - 125 mg/dl</td>
<td>≥126 mg/dl</td>
</tr>
<tr>
<td>Oral glucose tolerance test (OGTT)</td>
<td>&lt; 140 mg/dl</td>
<td>140 - 199 mg/dl</td>
<td>≥200 mg/dl</td>
</tr>
</tbody>
</table>

**Table 1:** Plasma glucose levels associated with normal, pre-diabetes and diabetes mellitus stages

4.3 Glycosylated Haemoglobin Test

The glycosylated haemoglobin (HbA1c) test is currently considered to be the best measure and the gold standard for assessing glycaemic control. The estimation of HbA1c level provides an accurate and objective measure of glycaemic control over past weeks to months (Hirsch & Parkin, 2005). The HbA1c test measures the amount of glucose that is bound to haemoglobin molecule. In normal conditions, red blood cells do not contain any glucose when they are formed. As the red blood cells move through the circulatory system, glucose molecules become attached to the haemoglobin molecules within red blood cells in an irreversible process known as glycosylation. The HbA1c test is based on the glycosylation process and measures the amount of glucose that is bound to molecules of haemoglobin A₁c (Delong & Burkhart, 2008). The higher the level of glucose in the blood, the more glucose molecules become attached to the haemoglobin within the red blood cells. The amount of glucose that is bound to the haemoglobin molecule reflects the average level of glucose that the cell has been exposed to over time (60 to 80 days). HbA1c test is used to determine if the patient has had glycaemic control over the past 3 months or not (Allen et al., 2008). Table 2 lists the guidelines for evaluating the results of the HbA1c test using the HbA1c glycaemic index. People with diabetes mellitus are considered under good control with HbA1c glycaemic index of less than 7%, moderate control 7-10% and poor control >10% (Delong & Burkhart, 2008).
<table>
<thead>
<tr>
<th>The HbA1c glycaemic index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>Good control</td>
</tr>
<tr>
<td>Moderate control</td>
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<tr>
<td>Poor control</td>
</tr>
</tbody>
</table>

Table 2: The HbA1c Glycaemic Index

### 4.4 Relationship between Glycaemic Control and Diabetes Complications

Several studies showed a significant association between diabetes mellitus complications and glycaemic control scores. It has been shown that diabetics suffering from various types of oral infections such as periodontal disease and mouth mucosal soreness also exhibited poor glycaemic control scores. A recent study showed a significant association \( p<0.05 \) between pain experience due to oral infections and glycaemic control scores among diabetic participants (Eldarrat, 2011a). As observed in the study, diabetic participants who indicated they always experienced pain due to oral infections over the last three months had poor glycaemic control (HbA1c >10%), while diabetic participants who indicated they occasionally experienced such pain had a moderate level of glycaemic control (HbA1c ≤8%), and those who never experienced pain had good glycaemic control (HbA1c <7%). Moreover, another study showed a significant association \( p<0.05 \) between dentate status of diabetics and their glycaemic control scores. It was found in the study the higher proportion of diabetic participants in the dentate group had lower glycaemic control scores (Allen et al., 2008). Furthermore, other investigators have shown a direct relationship between glycaemic control scores and the incidence of microvascular complications among people with diabetes (Hirsch & Parkin, 2005)

### 5 Complications of Diabetes Mellitus

Diabetic patients should be alerted that poor glycaemic control has negative consequences on their general health and health-related quality of life. When diabetic patients do not carefully control their blood glucose levels, their risk for serious systemic and oral complications will be much higher than diabetic patients with good control of their blood glucose levels.

#### 5.1 Pathophysiology of Diabetes Mellitus Complications

The serious complications of diabetes mellitus mostly arise as a result of macrovascular and microvascular complications (Steinberg, 1997; Steffes, 1997; Klein, 1997). The macrovascular complications include increased thickness of arterial walls, increased lipid deposition, atheroma formation and development of micro-thrombi. The increased arterial wall thickness results from growth factor-induced stimulation of smooth-muscle cell proliferation. The rise of growth factors in diabetic individuals is due to the oxidation of circulating low-density lipoprotein (LDL) which increases the oxidant stress within the vascular system (Brunzell and Chait, 1997). This leads to chemotaxis of monocytes and macrophages in blood vessel walls, where oxidised LDL causes alterations in cellular adhesion and increased production of cytokines and growth factors.
The microvascular complications arise from changes in endothelial basement membrane, due to proliferation of endothelial cells and changes in their function, which result in vascular permeability alterations. Another factor that causes diabetes mellitus complications is the formation of advanced glycation endproducts (AGE’s) which accumulate in the body plasma and tissues. The AGE’s are formed as a result of the metabolic dysregulation which lead to non-enzymatic glycation and oxidation of proteins, lipids and nucleic acids. The AGE’s binding to specific cellular receptors on the surface of monocytes and macrophages, rendering them hyper-responsive upon stimulation. This also leads to increased production of pro-inflammatory cytokines and growth factors which contribute to the chronic inflammatory processes of atherosclerotic lesions formation, altered wound healing and increased tissue destruction in response to antigens (Southerland et al., 2006; Nishimura et al., 2007).

5.2 Systemic Complications

Persistent hyperglycaemia in uncontrolled diabetic cases has repeatedly been reported to be associated with serious complications of diabetes mellitus, and these complications are responsible for the high rate of morbidity and mortality seen in the diabetic population (Mealey, 2000). The complications that result from persistent hyperglycaemia and lack of glycaemic control can be both chronic and acute complications.

The most common chronic complications are the macrovascular diseases (macroangiopathy), which include coronary artery, peripheral vascular and cerebrovascular diseases. The microvascular (microangiopathy) complications manifest as retinopathy, nephropathy, among other diseases. List of the systemic complications of diabetes mellitus due to long-standing persistent hyperglycaemia is shown in Table 3. The most common acute complications are diabetic ketoacidosis, hyperosmolar hyperglycaemia as well as other acute infections (Manfredi et al., 2004; Skamagas et al., 2008).

5.3 Oral Complications

In terms of diabetes mellitus oral consequences, the disease manifests itself in several ways. When diabetes mellitus is left uncontrolled for an extended period, it negatively affects the flow of salivary glands and results in xerostomia. It also causes sialosis, taste impairment, dental caries, periodontal disease, fungal infections, lichen planus, geographical tongue and fissured tongue (Sheppard, 1942; Russotto, 1981; Murrah, 1985; Lamey et al., 1992; Greenspan, 1996; Manfredi et al., 2004; Burt, 2005; Siudikiene et al., 2008). List of oral complications of diabetes mellitus is show in Table 3.

5.3.1 Xerostomia (Dry Mouth)

In xerostomia or dry mouth, the salivary flow is reduced to such an extent that the oral cavity loses the beneficial properties of saliva. Saliva plays a vital role in the mouth as it helps in talking, chewing, tasting, swallowing and digesting food. One of the most common consequences of xerostomia is diffused pain in the mouth “burning mouth syndrome” due to dry mucosal surfaces irritation, especially in patients wearing dentures (Manfredi et al., 2004). In addition, saliva controls the bacteria in the mouth, so lack of saliva would increase the risk of oral infections. When saliva secretion is not enough to wash and cleanse the oral cavity, oral biofilm and debris accumulate at a faster rate than in normal situation, this could be a factor in the increasing risk for dental caries (Rees, 1994; Finney et al., 1997). Moreover, saliva has a role in the sense of taste, impaired saliva production in patients with diabetes mellitus could account for the impairment of taste observed in some diabetic patients (Hardy et al., 1981). When the antimicrobial ac-
tions are negated in presence of high blood and saliva glucose levels, the growth and adhesion of yeast and Candida organisms is promoted (Knight & Fletcher, 1971; Odds et al., 1978; Samaranayake et al., 1984). The clinical manifestations of xerostomia are listed in table 4.

<table>
<thead>
<tr>
<th>Systemic Complications of Diabetes Mellitus</th>
<th>Oral Complications of Diabetes Mellitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vascular system</td>
<td>• Xerostomia (mouth dryness)</td>
</tr>
<tr>
<td>a. Macrovascular complications</td>
<td>• Periodontal disease</td>
</tr>
<tr>
<td>• Accelerated atherosclerosis</td>
<td>• Dental caries</td>
</tr>
<tr>
<td>• Coronary artery disease</td>
<td>• Sialosis</td>
</tr>
<tr>
<td>• Myocardial disease</td>
<td>• Taste impairment</td>
</tr>
<tr>
<td>• Ischaemic heart disease</td>
<td>• Fungal infections</td>
</tr>
<tr>
<td>• Cerebrovascular (stroke) disease</td>
<td>• Oral lichen planus</td>
</tr>
<tr>
<td>• Peripheral vascular disease</td>
<td>• Geographical and fissured tongue</td>
</tr>
<tr>
<td>• Gangrene of feet</td>
<td>• Sever TMJ dysfunction</td>
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<tr>
<td>b. Microvascular complications</td>
<td></td>
</tr>
<tr>
<td>• Retinopathy (vision changes, blindness)</td>
<td></td>
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<tr>
<td>• Nephropathy (renal failure)</td>
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<tr>
<td>2. Nervous system</td>
<td></td>
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<tr>
<td>• Peripheral sensory neuropathy (paraesthesia, anesthesia, reduced motor function)</td>
<td></td>
</tr>
<tr>
<td>• Autonomic neuropathy (abnormal pupillary reflexes, cardiac autonomic disturbance, postural hypotension, impotence)</td>
<td></td>
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<tr>
<td>3. Muscular system</td>
<td></td>
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<tr>
<td>• Myopathy (weakness &amp; exercise intolerance)</td>
<td></td>
</tr>
<tr>
<td>4. Alterations in wound healing</td>
<td></td>
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</tbody>
</table>

Table 3: List of the serious systemic and oral complications of diabetes mellitus

<table>
<thead>
<tr>
<th>Clinical manifestations of xerostomia</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dry mouth</td>
</tr>
<tr>
<td>• Thick saliva</td>
</tr>
<tr>
<td>• The feeling of not being able to swallow or talk properly due to sticky saliva</td>
</tr>
<tr>
<td>• Rough, dry, red tongue</td>
</tr>
<tr>
<td>• Dry feeling in the throat as well as the mouth</td>
</tr>
<tr>
<td>• Burning sensation in the mouth</td>
</tr>
<tr>
<td>• Sensitivity to salty or spicy foods</td>
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<tr>
<td>• Bad breath</td>
</tr>
<tr>
<td>• Mouth sores</td>
</tr>
<tr>
<td>• Cracked lips</td>
</tr>
<tr>
<td>• Difficulty wearing dentures</td>
</tr>
<tr>
<td>• Unusual thirst</td>
</tr>
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</table>

Table 4: The clinical manifestations of xerostomia
Gingivitis and periodontitis are the most common periodontal diseases affecting diabetics. Periodontitis is a chronic inflammatory disease, affecting 5-15% of the diabetic and non-diabetic populations (Burt, 2005). However, the prevalence of periodontitis is higher in individuals with diabetes (17%) than in individuals without diabetes (9%) (Soskoline & Klinger, 2001). Furthermore, diabetic patients with uncontrolled blood glucose levels have been shown to be three times more susceptible to develop periodontitis than those with normal blood glucose levels (Li CL, et al., 2002). It has also been shown that diabetic smokers at a higher risk of developing severe periodontitis than non-smoking diabetics (Skamagas et al., 2008).

The main causative factors for periodontal disease are poor oral hygiene and bacterial biofilms composed of anaerobic gram-negative microorganisms. Diabetes mellitus has been described as the risk factor for initiation and progression of periodontal disease (Albandar, 2002). The greater risk of periodontal disease progression was associated with type 2 diabetes mellitus and it can be considered a risk factor for periodontitis (Nilo et al., 2009). It has been suggested that diabetes mellitus alters bacteria-host interactions by prolonging the inflammatory response and dysregulating cytokine production (Naguib et al., 2004; Graves et al, 2005).

Periodontal disease is considered a risk factor for diabetes and its serious complications, such as vascular disease, neuropathy, and retinopathy. Several researchers have advanced the notion that there is a bidirectional relationship between periodontitis and diabetes mellitus (Bartolucci & Parkes, 1981; Ureles, 1983). They have suggested that not only does uncontrolled diabetes increase the patients’ susceptibility for developing periodontitis, but also severe periodontitis increases the risk for microvascular and macrovascular complications in diabetic patients (Thorstensson et al., 1995; the American Academy of Periodontology, 1999; Lalla & D’Ambrosio, 2001). The prevalence of diabetes mellitus in individuals with periodontitis is double that of individuals without periodontitis (Tsai et al., 2002).

Diabetes mellitus causes oral complications by pathological changes in oral microflora, phagocytic activity of the polymorphonuclear leucocytes and connective tissue. When this occur, the patient’s ability to fight off infection is impaired, which increases the possibility of developing periodontitis (Manfredi et al., 2004). Compared to non-diabetic patients, it has been shown by several investigators that diabetes mellitus may modulate periodontal tissue destruction by reducing the polymorphonuclear leukocyte function, chemotaxis, adherence, and phagocytosis (Manouchehr-Pour et al, 1981; McMullen et al, 1981). Moreover, other investigators reported that accumulation of advanced glycation end products in the periodontium, as a result of protein glycation due hyperglycaemia, stimulate monocytes to the site and interact with receptors on the cell surface of monocytes. The interaction between advanced glycation end products and monocyte receptors induces a change in monocyte phenotype, upregulating the cell and significantly increasing the production of pro-inflammatory cytokines, such as prostaglandin E2, interleukin (IL)-1β, IL-6 and tumor necrosis factor (TNF)-α (Salvi et al, 1998; Rachon et al, 2003). This may be a mechanism by which increased tissue loss may occur in people with diabetes mellitus. Diabetes mellitus-related changes associated with the development and progression of periodontal disease, due to impaired polymorphonuclear leukocyte function, collagen production and bone formation. These changes brought by the disease resulted in decreased host response, ability to maintain periodontal tissues and periodontal bone levels. While increased collagenase production and presence of advanced glycation end products led to increased periodontal tissue destruction and decreased healing/repair processes. Additionally, pathological changes in small blood vessels (microangiopathy) reduce blood flow to the periodontium and compromise the transfer of nutrients necessary to maintain tissue health (Delong & Burkhart, 2008).
Clinical studies provided evidence to support the fact that periodontal infections have an adverse effect on glycaemic control and may increase the risk for diabetes complications.

Investigators showed that treatment of periodontal infections in diabetic patients helps them in establishing and maintaining good glycaemic control and acts to delay the onset or development of the oral complications of diabetes (Taylor & Borgnakke, 2008). Moreover, two consecutive recent studies reported that the glycaemic control of sixty participants with type 2 diabetes mellitus and had moderate to severe periodontal disease was significantly improved after receiving effective non-surgical periodontal treatment consisted of scaling and root planning over a period of 6 months (Koromantzos et al., 2011; Koromantzos et al., 2012). Other investigators assessed the effect of periodontal therapy on glycaemic control for fifty-two diabetic patients, aged 55-80 years, with uncontrolled type 2 diabetes mellitus (HbA1c, 7.5-11.0%) and had severe periodontitis. In the study, the diabetic group received non-surgical periodontal treatment combined with systemic doxycycline 100mg per day for 14 days. They found that periodontal treatment significantly improved periodontal status of the diabetic group (P<0.05), and decreased the level of fasting plasma glucose (Promsudthi et al., 2005). Taking into consideration the aforementioned bidirectional relationship between periodontal diseases and diabetes mellitus, the prevention and treatment of periodontal diseases through proper oral hygiene and regular dental check-ups are of paramount importance for diabetic patients.

5.3.3 Dental Caries

Diabetics with elevated HbA1c levels exhibit higher levels of glucose in their saliva which combines with oral biofilm to form an acid, causing the salivary pH to drop. Salivary pH of >5 is critical for enamel demineralization and initiating the decay process. Siudikiene et al., (2008) have shown that in diabetic children, a high concentration of salivary glucose and albumin, as well as high oral biofilm scores were the single most important factors in diabetic children tooth caries. The investigators imply poor glycaemic control as a reason behind caries in children with diabetes mellitus. Similarly, patients with well-controlled blood glucose levels tend to have reduced caries rates (American Academy of Periodontology, 2000). On the other hand, another study revealed no response on the prevalence of caries among people with diabetes mellitus type 2 (Collin et al, 1998). It has been suggested that the increase in liability to caries among people with diabetes mellitus may be due to an increase in glucose concentration in saliva and gingival crevicular fluid, but it is also more likely that diabetic patients neglect oral hygiene due to gingival inflammation.

5.3.4 Sialosis

Sialosis is asymptomatic non-inflammatory, non-neoplastic enlargement of salivary glands. The enlargement of salivary glands is as a result of the fatty infiltration of interstitium and enlargement of acinar cells. Sialosis may increase the risk for calculus formation and obstruction of salivary ducts. It commonly affects parotid glands but submandibular glands can be affected (Donath and Seifert, 1975). It has been reported that 10-25% of people with diabetes mellitus may develop sialosis as a complication of longstanding diabetes mellitus (Murrah, 1985; Lamey et al., 1992). While other investigators reported only 3% of type 1 diabetic patients may develop sialosis (Guggenheimer et al., 2000).
5.3.5 Taste Impairment

People with diabetes mellitus lose the sweet taste of food, this sweet taste impairment is usually ignored, and as result undiagnosed diabetics may crave more sweet food causing further aggravation of their hyperglycaemia (Lamey et al, 1992). Diabetic patients with polydypsia and hyperglycaemia favour sugary drinks. The changes in taste sensation may indicate taste receptors abnormalities among diabetic patients (Hardy et al, 1981).

5.3.6 Fungal Infections

Diabetic individuals with uncontrolled diabetes are at increased risk of fungal infections (Lamey et al, 1992; Lalla and D'Ambrosio, 2001). Among candida species isolated from the oral cavity of diabetic patients; Candida albicans is the most prevalent (Willis et al, 1999) and Candida dubliniensis, (Willis et al, 2000; Manfredi et al, 2002). Oral candidosis is more dangerous to those with diabetes mellitus than to those without. Reports express a correlation between fungal infections and diabetes mellitus (Ueta et al, 1993; Guggenheimer et al, 2000b).

5.3.7 Oral Lichen Planus

Lichen planus often appears as white oral lesion and it can be seen intra-orally as striated network, bullous or erosive lesions. Studies have reported a low prevalence of oral lichen planus in people with diabetes mellitus. The prevalence reported by several investigators was 0.17% (Borghelli et al, 1993), 4% (Van Dis and Parks, 1995) and 3.65% (Petrou-Amerikanou et al, 1998). Erosive form of oral lichen planus has a higher prevalence than other forms in diabetic patients (Lundstrom, 1983; Bagan-Sebastian et al, 1992). These studies suggested that there is no strong relationship between oral lichen planus and diabetes mellitus. Scully and el Kom (1985) suggested a relationship between oral lichen planus, diabetes mellitus and hypertension, and the lesion most likely reflects lichenoid reactions associated with sulphon-lyureas and/or antihypertensive drug therapy, rather than lichen planus.

5.3.8 Geographic and Fissured Tongue

Geographic tongue is also known as benign migratory glossitis. Geographic tongue is characterized by inflammation patches affecting the dorsum of the tongue. Geographic and fissured tongue, may affect around 8% of the people with diabetes mellitus (Wysocki and Daley, 1987; Guggenheimer et al, 2000), and a higher prevalence of fissuring of the tongue has been reported in type 1 diabetes mellitus patients as a result of longstanding complication of diabetes mellitus (Guggenheimer et al, 2000). Even though, an association between geographic tongue and diabetes mellitus has been suggested by some investigators (Wysocki and Daley, 1987), such an association has not been reported by others (Guggenheimer et al, 2000).

5.3.9 Temporomandibular Joint Dysfunction

Temporomandibular joint dysfunction is a diversity of conditions that affect temporomandibular joints, jaw muscles and nerves, associated with chronic facial pain. It has been reported that peripheral diabetic neuropathy, as a consequence of longstanding diabetes mellitus, may be a risk factor for severe temporomandibular joint dysfunction (Collin et al, 2000).
6  Diabetic Patients’ Awareness and Attitude towards Their Oral

6.1  Diabetics’ Awareness of Diabetes Mellitus Disease

The prevalence of diabetes worldwide has been increasing epidemically. It is estimated by WHO that 366 million people are expected to suffer from diabetes mellitus by 2030. The recent rise in diabetes is not a genetic shift only but also an environmental shift as a result of lifestyle habits. The prevalence of type 2 diabetes is higher than type 1 diabetes. The majority of people with diabetes have type 2 diabetes (90-95%), unfortunately, most of these people are unaware that they have diabetes mellitus (Delong & Burkhart, 2008). However, some diabetics know that they have the disease but do not know which type of diabetes they have although they are under diabetes medications. The disease may stay “silent” and the majority of people with diabetes mellitus do not realize they have diabetes mellitus until serious complications occur. Eldarrat (2011a) found among diabetic participants, 71% had type 2 diabetes, 18% of the participants suffered from type 1 and 11% did not know which type of diabetes they had. Similarly, another study showed that more than half of the diabetic participants (58%) had type 2 diabetes, 26% had type 1, and 16% did not know what type of diabetes they had (Eldarrat, 2011b). Other investigators found 27% of diabetic participants had type 1 diabetes, 66% type 2 and 7% did not know what type of diabetes they had (Allen et al., 2008).

6.2  Diabetics’ Awareness of Their Increased Risk for Complications

Reported evidence clearly confirms that people with diabetes have more knowledge about their increased risk for systemic complications associated with diabetes than they do for oral complications. Several recent studies reported that diabetic patients are much less informed of their risk for oral diseases in comparison with their knowledge of their increased risk for systemic diseases (Bowyer et al., 2011; Eldarrat 2011a; Eldarrat 2011b; Allen et al., 2008). Bowyer et al., (2011) found the people with diabetes have poor awareness of oral care and health complications associated with diabetes mellitus. Likewise, Eldarrat (2011a) assessed the awareness of two hundred diabetic patients for their increased risk for systemic and oral diseases, and found the percentage of diabetic participants’ awareness of their increased risk for eye disease 90%, heart disease 83%, kidney disease 83%, periodontal disease 66%, oral fungal infection 47%, and dental caries 44%. Another study showed that the percentage of diabetic participants who were aware of their increased risk for eye disease was 85%, heart disease 75%, kidney diseases 90%, periodontal disease 60%, dental caries 54% and oral fungal infections 42% Eldarrat (2011b). Similar findings were reported by other researchers, who assessed the knowledge of one hundred and one diabetic patients of their risk for periodontal disease, their attitude towards oral health and their oral health-related quality of life. Those researchers found that 98% of the diabetic participants were aware of their increased risk for eye disease, 84% for heart disease, 94% for kidney disease and 33% for periodontal disease (Allen et al., 2008). Furthermore, in the same study, the diabetic participants with HbA1c levels >9%, which represents poor glycaemic control and at the highest risk for periodontal disease, 62% of these diabetic participants were unaware of their risk for periodontal disease (Allen et al., 2008).

6.3  Diabetics’ Awareness of Their Increased Risk for Dry Mouth

The knowledge of diabetic patients of their increased risk for oral diseases such as periodontal disease, tooth caries and fungal infections as a result of dry mouth is inadequate. More than 70% of the diabetic participants were suffering from dry mouth and, of these, 60% were unaware of the serious consequences
of dry mouth on their oral health (Eldarrat, 2011b). It is well known that a significant reduction of saliva-
flow leading to dry mouth, and it is the most common oral manifestation of diabetes mellitus. It is of
paramount importance to inform and make diabetics aware of the beneficial properties of saliva. Saliva’s
function of washing and cleansing the oral cavity is known to prevent the accumulation of oral biofilm
and debris. The accumulation of oral biofilm could be a contributing factor to increase the risk for peri-
dontal disease and dental caries in diabetics (Rees, 1994; Finney et al., 1997). In addition, saliva has an-
timicrobial actions, when these actions are impaired, in presence of high blood and saliva glucose con-
centrations, the risk Candida organisms’ growth is increased (Manfredi et al., 2004). Therefore, diabetics
should be informed and educated about the importance of keeping the oral cavity moist by stimulating
salivary flow and frequent water drinking.

6.4 Diabetics’ Awareness of Periodontal Disease

Serious periodontal disease not only can cause tooth loss, but can also cause changes in the shape of bone
and gingival tissues. The gingival tissues become uneven, and dentures may not fit well. Diabetics often
have sore gums from dentures. If chewing with dentures is painful, individuals with diabetes might
choose foods that are easier to chew but not right for their diet and overall health. Eating the unhealthy
foods can disturb blood sugar level (Allen et al., 2008). It has been shown that the common knowledge of
people with diabetes of periodontal disease signs is bleeding during brushing. It has been found that the
majority of diabetics were aware that bleeding during brushing (70%), swollen and red-colored gingival
(63%), and soreness of gingival (19%) are the signs of periodontal disease (Eldarrat, 2011b). Evidence is
emerging to confirm the bidirectional relationship between diabetes mellitus and periodontal disease. Peri-
dontal disease is one of the chronic infections which affect glycaemic control and associated with in-
creased risk for diabetes complications. Awareness of diabetic patients and their physicians of the role of
periodontal disease in glycaemic control of diabetics is important to maintain good oral health, glycaemic
control and possibly delay the onset or progression of diabetic complications.

6.5 Diabetics’ Awareness of the Influence of Oral Health on Overall Health

The influence of oral health on overall health of people with diabetes has been confirmed by several in-
vestigators. Many studies in the literature have highlighted the effect of periodontitis on diabetes melliti-
us. As reported by the previous studies that severe periodontitis may increase patients’ susceptibility to
develop diabetes and raise their risk for diabetes serious complications (Thorstensson et al., 1995; the
American Academy of Periodontology, 1999; Lalla & D’Ambrosio, 2001). Several investigators reported
that periodontitis may initiate and/or accelerate insulin resistance in the body by enhancing the systemic
immune response activation, initiated by cytokines (Salvi et al., 2008; Mealey and Rose, 2008). A paral-
lel relationship has been suggested between the severity of periodontitis and blood cytokine (TNF-α) lev-
eels, which is closely linked to insulin resistance (Engebretson et al., 2004). The predominance of gram-
negative anaerobic bacteria in periodontal infection may serve as a chronic source of systemic bacteremia
and locally produced inflammatory mediators like Tumour Necrosis Factor (TNF-a), Interleukins (IL1 &
IL6) and Prostaglandin (PGE2) by monocyte cells. These mediators have been shown to have effects on
glucose and lipid metabolism and to antagonize insulin action in the body (Ling et al., 1995). Further-
more, several clinical studies using non-surgical periodontal therapy reported a beneficial effect of peri-
dontal therapy on glycaemic control of people with diabetes mellitus (Grossi et al., 1997; Rodrigues et
al., 2003; Kiran et al., 2005). Poorer glycaemic control has been shown to be associated with increased
levels of cytokines, in the gingival crevicular fluid in individuals with type 2 diabetes mellitus and perio-
dontitis (Engebretson et al., 2004). Moreover, a significant association was shown between dentate status of diabetics and their glycaemic control scores, as a higher proportion of diabetic patients in the dentate group were found to have lower glycaemic control scores (Allen et al., 2008). Another study reported that the majority of the edentulous diabetic participants (66%) did not have dentures and ate selected soft foods which were easy to chew and swallow (Eldarrat 2011b). Thus, edentulous people with diabetes are deprived of the benefits of eating healthy food. This has negative consequences on their glycaemic control, general health and health-related quality of life. Therefore, awareness of people with or without diabetes mellitus of the associations between oral health and overall health is the first crucial step to prevent and control the disease.

6.6 Diabetics’ Attitude towards Their Oral Hygiene

Maintaining proper oral hygiene through oral self-care is also lacking in diabetic patients. A recent study assessed diabetic patients’ attitude toward using a toothbrush and dental floss as part of their oral self-care, indicated that 19% of the diabetic respondents did not use a brush on a daily basis, 31% brushed twice a day, and a significantly higher number of respondents (50%) brushed once a day. In addition, a significant proportion (66%) never used dental floss to clean between their teeth, 11% reported using dental floss once a day, and 23% did not use it on daily basis (Eldarrat, 2011b). Similar results were reported by several investigators who found that of 299 participants only 29% brushed their teeth on a twice-daily basis (Bakhshandeh et al., 2008). Bowyer et al., (2011) found a significant number of respondents (67.2%) brushed their teeth at least twice a day, whereas only 15.3% used dental floss on daily basis. Other investigators found that diabetic women reported brushing their teeth more frequently than diabetic men and the differences in plaque and calculus indices were significantly lower in diabetic women than those of diabetic men (Karikoski et al., 2001).

6.7 Diabetics’ Attitude towards Their Regular Dental Check-ups

In fact, regular dental check-up visits are essential and may help in the detection of diabetic cases, in particular those who are unaware of the disease. Dental professionals are frequently the first to identify and refer patients with diabetes mellitus because of the oral findings from routine oral examinations. Investigators have reported that good oral condition is strongly associated with frequent dental visits (Karikoski et al., 2001). The same investigators showed a significant association only between frequent dental visits and reduced amount of calculus, when they assessed the effects of oral self-care on periodontal health among adults with diabetes (Karikoski et al., 2001). Even though, regular dental check-up visits are important to keep good oral health for diabetic patients, several investigators clearly showed that diabetic participants' attitude towards their oral health by keeping regular dental check-ups is poor. A study showed that about 40% of the diabetic participants had not visited a dental clinic for one year, and the main reason to visit a dental clinic was to receive treatment for pain and/or discomfort (Eldarrat, 2011b).

Moreover, in various surveys, investigators showed that the percentages of diabetic patients who kept regular dental check-ups were 37% (Kelly et al., 1998), 47% (Allen et al., 2008), 59% (Bakhshandeh et al., 2008), 14% (Eldarrat, 2011b) and 79.8% (Bowyer et al., 2011).

6.8 Diabetics’ Attitude towards Keeping Their Teeth

A study assessed the response and decision made by diabetic patients about whether they would wish to save a loose tooth. 24% of diabetic participants would prefer extraction for a loose posterior tooth and
16% of an anterior tooth without consent. Diabetic participant response towards dentist consent before extraction of a loose anterior tooth was favored by 70%. Time and cost factors were less likely to influence the consent for extraction of either anterior or posterior tooth (Eldarrat, 2011b).

### 6.9 Diabetics’ Sources of Awareness

Sources of knowledge and awareness of people with diabetes mellitus for their increased risk of oral diseases were found inadequate and receiving limited advice from healthcare professionals. Bowyer and co-investigators reported that 69% of diabetic respondents had never received any oral health advice related to their diabetes. The authors concluded that many adults with diabetes have poor awareness of oral care and health complications associated with diabetes. Training and advice for both healthcare professionals and patients concerning the importance of good oral health in patients with diabetes are needed (Bowyer et al., 2011). Other studies showed that the source of information for diabetic patients regarding their increased risk for oral diseases mainly came from a dentist, and other sources such as television programs, the internet, magazines, and friends (Eldarrat 2011a & Eldarrat 2011b). In fact, it is the dentist's role to be a part of the healthcare team in order to help reduce the incidence and adverse impact of diabetes mellitus on oral health (Ali and Kunzel, 2011).

### 7 Conclusion

The dramatic increase of the global prevalence of diabetes among adults and children is attributed to a genetic shift and an environmental shift as a result of modern lifestyle habits such as unhealthy diet, obesity, physical inactivity. Despite the worldwide recognition of the dangers of diabetes mellitus, diabetic patients’ awareness of and attitudes toward their increased risk for oral diseases has not been fully addressed. Diabetic patients are much less informed of their risk for dental diseases in comparison with their knowledge of their increased risk for systemic diseases. Thus, it is necessary for dental professionals and related government agencies to promote awareness of the relationship between diabetes mellitus and oral heath in order to prevent harmful complications. Education programmes to increase public awareness as a first step to prevent the disease and long-term complications. Health professionals in both the dental and medical fields and as well as the nutritionists need to take the responsibility to develop programs to educate the public about diabetes mellitus and the serious oral and systemic complications of the disease.

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### References


