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Dent Clin N Am 50 (2006) 591–606

THE DENTAL
CLINICS
OF NORTH AMERICA

Dental Management of Patients with Diabetes

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Diabetes mellitus (DM) is a disease of glucose, fat, and protein metabolism resulting from impaired insulin secretion, varying degrees of insulin resistance, or both. Hyperglycemia is the most clinically important metabolic aberration in DM and the basis for its diagnosis. Apart from the obvious impact of impaired glucose metabolism, DM and chronic hyperglycemia are associated with important ophthalmic, renal, cardiovascular, cerebrovascular, and peripheral neurological disorders. Management of the diabetic dental patient must take into consideration the impacts of diabetes on dental disease and dental treatment, as well as a clear appreciation for the comorbidities that accompany long-standing DM.

Classification

Most cases of DM can be classified as type 1 (formerly, insulin-dependent diabetes) and type 2 (formerly, noninsulin-dependent diabetes). Blood glucose elevation that does not satisfy the definition of type-1 or type-2 DM is classified as impaired glucose tolerance or impaired fasting glucose.

Secondary forms of DM also exist (Box 1). For example, diseases of the pancreas, such as pancreatitis, may produce a state of absolute insulin deficiency. Numerous drugs may create a diabetic state, glucocorticoids being the most notable. Glucocorticoids not only increase insulin resistance in liver and muscle, but also impair the response of pancreatic beta cells to elevated plasma glucose. Recognition of secondary forms of DM is important because removal or management of the underlying cause can reverse the diabetic condition.

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doi:10.1016/j.cden.2006.06.008 *dental.theclinics.com*

Box 1. American Diabetic Association classification of diabetes mellitus

Type 1
- Immune mediated
- Idiopathic (type 1B)

Type 2
Other specific types
Genetic pancreatic beta-cell defects
Genetic defects in insulin receptor
Pancreatic disease
- Trauma
- Infection
- Inflammation
- Neoplasm

Endocrinopathies
- Growth hormone (acromegaly)
- Cortisol (Cushing's syndrome)
- Glucagon (glucagonoma)
- Epinephrine (pheochromocytoma)

Drug- or chemical-induced
- Nicotinic acid
- Glucocorticoids
- Thyroid hormone
- Phenytoin
- Thiazides

Infections
- Viral infection
  Rubella
  Coxsackievirus B
  Cytomegalovirus
  Adenovirus
  Mumps

Uncommon immune-medicated
- Anti-insulin receptor antibody
- Stiff-man syndrome

Other genetic syndromes
- Down's syndrome
- Turner syndrome
- Klinefelter's syndrome
- Wolfram's syndrome

Gestational diabetes mellitus
Impaired glucose tolerance, impaired fasting glucose

Another form of DM less likely to present in the dental care setting is gestational diabetes or DM presenting during pregnancy. Gestational diabetes is the result of insulin production insufficient to overcome insulin resistance produced by placental anti-insulin hormones (eg, estrogen, prolactin, cortisol).

Epidemiology

Type-1 DM accounts for 5% to 10% of cases of DM in the United States, Canada, and Europe. Based on 1995 data, the prevalence of type-1 DM in the United States is 1.7 per 1000 in those younger than 19 years and 2.1 per 1000 in adults [1]. Estimates of the annual incidence of type-1 DM are 18 per 100,000 in those 19 years of age and younger and 9 per 100,000 in those over 19 years of age. Approximately 30,000 cases of type-1 DM are diagnosed yearly in the United States. Type-1 DM is more common in whites than in African-Americans.

Type-2 DM accounts for 80% of cases of DM in the United States, Canada, and Europe [1]. Based on 1994 data, the prevalence of type-2 DM is 51 per 1000 for those 20 years of age and older [2]. For those in the 40-to-74-year age group, the prevalence increases to 123 per 1000. There are an estimated 10.2 million diagnosed and 5.4 million undiagnosed cases of type-2 DM in the United States. African-American women have nearly twice the incidence of diabetes as non-Hispanic white women. Mexican-American men have a 50% greater prevalence than their non-Hispanic white counterparts [3]. The annual incidence of type-2 DM is 180 per 100,00 population in those 25 to 44 years of age and 680 per 100,000 population in those 65 to 74 years of age. Approximately 625,000 cases of type-2 DM are diagnosed each year in the United States [3].

Diagnosis

The diagnosis of DM is based on the measurement of fasting plasma glucose (FPG) or plasma glucose 2 hours following a 75-gm oral glucose challenge (oral glucose tolerance test (OGTT)). Normal plasma glucose is defined by the American Diabetic Association (ADA) as a FPG $<$100mg/dL [4]. The diagnosis of DM is straightforward in the patient who presents with classic symptoms of polyuria, thirst, weight loss, fatigue, visual blurring, and a FPG $\geq$126 mg/dL, or a random value of at least 200 mg/dL. The diagnosis of DM should be confirmed by plasma glucose evaluation on a subsequent day. In the absence of these classic symptoms, glucose intolerance may exist as impaired fasting glucose (IFG) when the FPG is between 100 and 125 mg/dL. Similarly, plasma glucose of 140 to 199 mg/dL following OGTT defines impaired glucose tolerance (IGT). The classification of IFG and IGT is important because individuals with IFG and IGT are at greater risk of developing diabetes and atherosclerotic cardiovascular disease even if they do not develop DM [5].

There is an important distinction between testing for suspected DM and screening for undiagnosed and clinically unsuspected DM. Whereas type-1 DM often presents with markedly elevated plasma glucose and associated symptoms, type-2 DM is often not diagnosed until complications occur. This makes screening for type-2 DM especially important. The ADA recommends FPG screening in individuals 45 years of age every 3 years, especially if obese [6]. Screening should be considered at a younger age or performed more frequently in individuals who are overweight (body-mass index >25), have a sedentary lifestyle, have a first-degree relative with DM, or who have been diagnosed with hypertension, hyperlipidemia, or vascular disease.

Regulation of blood glucose

Diabetes has an impact on a number of fundamental metabolic processes. Glucose homeostasis is the result of the relative influences of two opposing hormones, insulin and glucagon. Insulin is a protein synthesized in the pancreatic beta cells. It exerts its biochemical effects by interacting with transmembrane cellular receptors. The principal role of insulin is to facilitate storage of glucose as glycogen, free fatty acids as triglycerides, and amino acids as protein. Insulin also inhibits the breakdown of glycogen, lipids, and protein. Furthermore, insulin inhibits ketogenesis and gluconeogenesis. Insulin therefore has its most important effect on muscle and adipose tissues and on the liver. Glucagon supports opposing activity by stimulating glucose and fatty acid formation, ketogenesis, and conversion of amino acids to glucose. Following a meal, plasma insulin increases, altering the relative activity of insulin and glucagon in favor of insulin. As a result, dietary carbohydrate is stored in muscle and liver in the form of glycogen. Free fatty acids are converted to triglycerides in fat and amino acids are converted to protein. As plasma glucose returns to its preprandial value, so too does insulin secretion, and the preprandial insulin/glucagon ratio is reestablished.

The sensitivity of target tissue to insulin is an important determinant of insulin effect. Feedback mechanisms increase insulin release in individuals who are relatively insulin resistant and decrease insulin release if there is increased tissue sensitivity. Target-tissue insulin sensitivity plays an important role in the pathophysiology of type-2 DM.

Pathophysiology of type-1 diabetes

Type-1 DM is characterized by an absolute insulin deficiency brought about by the autoimmune destruction or accelerated disappearance of pancreatic beta cells [7]. However, some patients have no evidence of an autoimmune mechanism. Such patients are said to have type-1B DM [8]. Mononuclear lymphocytic infiltrates, principally T lymphocytes [9], have been identified in pancreatic islets in individuals with type-1 DM [10]. Also, autoantibodies to a number of beta-cell antigens can be identified in the

sera of those with type-1 DM [11]. Such autoantibodies can be detected well in advance of the onset of clinical diabetes and in some first-degree relatives of individuals with type-1 DM. In fact, high autoantibody titers in relatives of diabetics are harbingers of the development of clinical diabetes within a few years [12]. Novel immunosuppressive treatment of recently diagnosed type-1 DM can decrease or even eliminate the need for exogenous insulin administration [13]. However, the potential toxicity of continuous immunosuppressive therapy precludes its clinical application in DM treatment.

Susceptibility to type-1 DM is inherited and the principle gene associated with this genetic predisposition is the major histocompatability complex (MHC) on chromosome 6. A number of HLA genes have been implicated in the familial clustering of type-1 DM [14]. The life-long risk of developing diabetes is 6% in offspring and 5% in siblings of affected individuals [15].

Apart from the underlying role of genetics, environmental factors are also believed to play an important role in the pathogenesis of type-1 DM. For example, 90% of newly diagnosed type-1 diabetics do not have an affected first-degree relative [16] and nearly 50% of monozygotic twins are discordant for DM [17]. Several pregnancy and perinatal factors, such as maternal age >25 years, preeclampsia, neonatal respiratory disease, and jaundice, have been associated with the development of type-1 DM [18]. Viral infection has also been implicated in the destruction of beta cells or as a trigger for the production of autoantibodies [19]. For example, the congenital rubella syndrome is associated with an increased risk of developing type-1 DM [20]. Early exposure to cow's milk has also been implicated in the development of type-1 DM in childhood [21].

The pancreas has a substantial reserve for insulin production and clinical DM does not occur until 90% of beta cells have been eliminated [22]. The end result of an absolute insulin deficiency is impaired glucose uptake by muscle and fat as well as a loss of insulin-induced suppression of liver glucose production. FPG may rise to 300 to 400 mg/dL and post-prandial levels as high as 500 to 600 mg/dL [23]. This produces an osmotic diuresis with polyuria and, subsequently, increased thirst. Plasma fatty acid levels increase as does hepatic uptake of free fatty acids. This, in turn, leads to increased production of ketoacids and metabolic acidosis (diabetic ketoacidosis). Weight loss occurs as a result of protein catabolism and lypolysis.

Pathophysiology of type-2 diabetes

The pathophysiology of type-2 DM is complicated by the fact that patients present with varying degrees of both insulin deficiency and insulin resistance [24]. In contrast to type-1 DM, hyperglycemia in type-2 DM is principally a result of insulin resistance [25]. The eventual loss of the ability of the pancreas to increase insulin output, in the setting of insulin resistance, creates a relative insulin deficiency and progression to established type-2 DM [26]. Hyperglycemia itself may contribute to insulin deficiency through

a toxic effect (glucose toxicity) on pancreatic beta cells. Thus, hyperglycemia promotes hyperglycemia [27]. The practical implication of this complex interaction between insulin resistance and insulin production is that any clinical measure taken to normalize plasma glucose will improve glucose homeostasis. Although adverse effects on fatty acid metabolism are seen, in contrast to type-1 DM, there is usually sufficient residual insulin secretion in type-2 DM to limit ketoacid formation and prevent the development of clinical acidosis. Some type-2 diabetics also manifest pancreatic islet-cell autoantibodies typical of type-1 DM and experience a more rapid decline in beta-cell function than those without autoantibodies [28].

In contrast to type-1 DM, genetics significantly influence the development of type-2 DM. The lifetime risk for a first-degree relative of an affected individual is 5- to 10-fold the risk in an age- and weight-matched population without a family history of DM [29]. Monozygotic twin concordance for type-2 DM is nearly 90% [17]. Unlike type-1 DM, no HLA gene markers demonstrating susceptibility to type-2 DM have been identified. Type-2 DM probably represents a multigenic disorder [22].

Obesity, especially of long duration, is an important risk factor for the development of type-2 DM [30]. Abdominal obesity (waist >102 cm in men, >88 cm in women), in particular, is an important risk factor for type-2 DM and is associated with insulin resistance [31]. Type-2 DM is often accompanied by other conditions in addition to obesity. These include hypertension, elevated serum low-density–lipoprotein cholesterol, low serum high-density–lipoprotein cholesterol. The clustering of metabolic risk factors for both type-2 DM and cardiovascular disease has prompted the diagnosis of "metabolic syndrome" [32]. The metabolic syndrome is considered a pro-inflammatory, prothrombotic state that is a significant predictor of type-2 DM and cardiovascular disease [33].

Complications of diabetes

Chronic elevation of plasma glucose leads to increased intracellular accumulation of glucose and its metabolic products [34]. The resulting long-term complications include microvascular disease of the eye (retinopathy) and kidney (nephropathy) and a variety of neuropathies [35]. Diabetic retinopathy occurs in all forms of DM with the earliest manifestations being retinal microaneurysms. With progression, affected vessels become occluded and retinal infarctions follow. Vessel proliferation can lead to vitreous hemorrhage, fibroproliferative changes with retinal traction, and vision loss.

Diabetic nephropathy affects 30% of patients with type-1 DM and 4% to 20% with type-2 DM [34]. Beginning as thickening of the capillary basement membrane, deposition of protein ultimately leads to glomerulosclerosis, impaired renal function, and progression to renal failure. If a person does not develop nephropathy after having diabetes for 25 to 30 years, then it is

unlikely he or she will develop the condition [36]. This is unlike diabetic retinopathy, where risk continuously increases over time.

Diabetic neuropathy has many possible manifestations [35]. The most common presentation is symmetrical altered sensation in the toes and feet. A minority of patients experience a painful, burning character to the neuropathy. Motor-nerve involvement is less common but may involve both cranial and peripheral nerves. Cranial nerve neuropathies may present with extraocular muscle weakness and double vision. Finally, involvement of the autonomic nervous system can affect gastric motility, erectile function, bladder function, cardiac function, and vascular tone.

Cardiovascular disease occurs with greater frequency in diabetics than in the general population. Seventy-five percent of type-2 diabetics die of cardiovascular disease [37]. As noted, type-2 diabetics with the metabolic syndrome have a clustering of risk factors for cardiovascular disease (eg, obesity, dyslipidemia, and hypertension). The prevalence of coronary artery disease in type-2 DM with the metabolic syndrome is twice that in individuals without diabetes or metabolic syndrome [38]. Coronary artery disease develops at an earlier age in diabetics, and atypical anginal symptoms and congestive heart failure are a more common presentation [39]. The risk of a first myocardial infarction in patients with DM is equal to that of recurrent infarction in nondiabetics [40].

Though some disagree, it is generally held that diabetes with poor plasma glucose control is associated with an increased risk of infection. Surgical site infection, especially, is more common in the setting of uncontrolled DM and hyperglycemia [41]. For example, elevated preoperative glucose levels (>200 mg/dL) are associated with deep wound infection after cardiac surgery [42]. Neutrophil adherence, chemotaxis, phagocytosis and bactericidal activity, and cell-mediated immunity are all compromised in the hyperglycemic diabetic [43,44]. The plasma glucose threshold for such granulocyte dysfunction is in the range of 198 to 270 mg/dL [45]. Both granulocyte [46] and T-cell [47] dysfunction are reversed by the administration of insulin. The practical implication of diabetic-associated immune dysfunction is that optimal control of plasma glucose is important both in the prevention of infection and in the management of established infection.

Oral manifestations of diabetes

Independent of the severity of plaque accumulation, gingivitis, periodontitis, and periodontal bone loss are associated with DM, especially when poorly controlled [48–51]. Defects in immune status, altered bacterial flora, and microvascular disease are the postulated pathogenesis of diabetic periodontal disease [52]. Evidence also indicates that bacteremia associated with periodontitis contributes to insulin resistance and destruction of pancreatic islet cells [53]. Diabetic patients may complain of dry mouth. Xerostomia

may be a manifestation of hyperglycemia-associated dehydration or impaired salivary gland function [54]. Oral candida infections occur with greater frequency in poorly controlled diabetics [55].

Management of diabetes

Intensive diabetes control directed toward near-normalization of plasma glucose has beneficial effects on the development and progression of diabetic retinopathy, nephropathy, and neuropathy [56]. Nonsignificant reduction in the incidence of myocardial infarction has been reported in patients with type-2 DM and intensive measures to control serum glucose [57]. Cardiovascular risk reduction in diabetes should focus on management of well-established risk factors for cardiovascular disease, including hypertension, dyslipidemia, obesity, smoking, and sedentary lifestyle. Management of hypertension in the diabetic, in addition to reducing the risk of cardiovascular complications, reduces or delays progression of diabetic retinopathy and nephropathy [5,58].

Type-1 diabetes

The cornerstone of type-1 DM management is patient monitoring of blood glucose and administration of insulin to achieve near-normal blood glucose levels. Periodic evaluation of glycosylated hemoglobin (HbA_{1c}) at the physician's office provides an estimate of average blood glucose levels over the preceding 2 months. Blood glucose should be evaluated at least before each meal and large snacks to assist in the administration of the appropriate mealtime insulin dose. There are a variety of insulin preparations that differ with regard to time of onset, peak effect, and duration (Table 1). There are also a variety of methods to estimate an insulin dose. The goal of insulin therapy is to mimic as closely as possible insulin secretion of the normal pancreas in response to natural fluctuations in blood glucose with meals, sleep, and exercise. To this end, basal insulin production is usually mimicked with the use of a long-acting insulin preparation and post-prandial insulin requirements are satisfied with administration of a rapid-onset, short-acting insulin preparation at mealtime. Estimation of the correct dose of short-acting, rapid-onset insulin is usually calculated by the preprandial blood glucose level and the carbohydrate content of the planned meal. An alternative to multiple daily insulin injections is the use of a continuous infusion pump. Regardless of the insulin regimen, nutritional consistency as to timing and composition of meals is important in type-1 DM. Fifty percent of the diet calories should come from carbohydrates with $<30\%$ total fat calories [59]. Insulin requirements predictably increase with increased carbohydrate consumption, decreased physical activity, weight gain, onset of puberty, physiological stress from infection or other acute medical or surgical conditions, pregnancy, and glucocorticoid administration.

Table 1
Insulin preparations

Insulin type	Time of onset	Peak effect	Duration
Rapid-acting			
Lispro	10–30 min	30–60 min	3–5 h
Aspart	10–30 min	30–60 min	3–5 h
Glulisine	10–30 min	2 h	3–5 h
Inhaled	10–30 min	30–60 min	3–5 h
Short-acting			
Regular	30–60 min	1.5–2 h	5–12 h
Intermediate-acting			
NPH, lente	1–2 h	4–8 h	10–20 h
Long-acting			
Ultralente	2–4 h	8–20 h	16–24 h
Glargine	1–2 h	No peak	24 h
Detemir	2–4 h	No peak	20 h

Exercise is also important because of its beneficial effect on insulin sensitivity and cardiovascular health. Therefore, an individual's insulin regimen must also take into account energy expenditure from exercise. Replenishment of muscle glycogen stores from plasma glucose following exercise can precipitate clinically significant hypoglycemia if diet and insulin administration have not been carefully matched. Through manipulation of diet, exercise, and insulin administration, the goal of blood sugar control is to achieve a HbA_{1c} of $<7\%$. This level of control is associated with fewer long-term microvascular complications [60]. An important paradox of intensive insulin therapy for type-1 DM is weight gain and even obesity leading to increased insulin resistance characteristic of type-2 DM.

Prolonged marked hyperglycemia in the type-1 diabetic may culminate in the life-threatening clinical condition of diabetic ketoacidosis (DKA). DKA is the result of insulin deficiency often precipitated by stress-related elevation of glucagon, cortisol, growth hormone, and catecholamines [61]. The presenting signs and symptoms of DKA are dehydration, nausea, vomiting, hyperventilation, and possible mental status changes. Laboratory analysis will usually reveal marked hyperglycemia, electrolyte imbalances, and acidosis. The treatment of DKA consists of hydration, insulin administration, and correction of electrolyte abnormalities.

Type-2 diabetes

As with type-1 DM, the goal of treatment of type-2 diabetes is near-normal plasma glucose regulation with a HbA_{1c} $<7\%$. Management of hyperglycemia in the type-2 diabetic is a complex process that often involves a stepwise regimen of diet modification, oral glucose-lowering medications, lifestyle adjustments, and, ultimately in some individuals, insulin administration. Because of the association with obesity, diet modification and increased

physical activity are critical elements in the management of type-2 DM. Another important component of the lifestyle change is smoking cessation because of the salutary effect this can have on cardiovascular and microvascular disease risk. As noted, hypertension (blood pressure $>140/90$ mm Hg) is a common comorbidity of DM and is an important element in the metabolic syndrome of DM. To bring blood pressure into the 130/80-mm-Hg range, antihypertensive medication or medications may be required, in addition to measures for weight loss and restrictions of dietary sodium, fat, and alcohol. Finally, type-2 diabetics have an increased prevalence of lipid abnormalities that should be addressed through diet modification, smoking cessation, exercise, and administration of a variety of lipid-lowering drugs.

Oral medications to lower serum glucose are recommended where diet and lifestyle changes alone are unsuccessful in controlling type-2 DM. A variety of oral agents are available with different mechanisms of action (Table 2). The most commonly used classes of oral glucose-lowering drugs are the sulfonylureas and biguanides. Sulfonylureas decrease plasma glucose by stimulating insulin release, while biguanides decrease plasma glucose by increasing hepatic insulin sensitivity. Other oral glucose-lowering drugs serve a secondary role in managing type-2 DM. Examples include the alpha-glycosidase inhibitors, which inhibit small-intestine glucose absorption; thiazolidinediones, which increase peripheral glucose uptake by decreasing muscle and adipose tissue insulin resistance; and meglitanides, which stimulate insulin secretion. The biguanide metformin is a popular first-line oral agent because, among users, hypoglycemia almost never occurs, weight gain is uncommon, and unfavorable serum lipid abnormalities are favorably altered [62]. Newer

Table 2
Oral hypoglycemic agents

Mechanism of action	Duration	Risk of hypoglycemia
Increase insulin release		
Second generation sulfonylureas		
Glipizide	14–16 hours	Yes
Glyburide	20–24+ hours	Yes
Glimepride	24+ hours	Yes
Meglitinides		
Repaglinide	24 hours	Yes
Nateglinide	4 hours	Yes
Increase insulin-receptor sensitivity		
Biguanide		
Metformin	24+ hours	No
Thiazolidinediones		
Rosiglitazone	Weeks	No
Pioglitazone		No
Modify intestinal glucose absorption		
Alpha-glucosidase inhibitors		
Acarbose	3–4 hours	No
Miglitol	3–4 hours	No

injectable drugs include exentide, whose action enhances glucose-dependant insulin secretion, and pramintide, whose action suppresses glucagon secretion. Finally, insulin administration, using regimens similar to those applied to the management of type-1 DM, may be necessary to control plasma glucose levels in type-2 DM.

Analogous to DKA in type-1 diabetics, type-2 diabetics can experience a state of hyperosmolar nonketotic coma when serum glucose levels are extremely elevated (eg, 600 mg/dL). In contrast to the condition of DKA in the type-1 diabetic, in type-2 DM, ample residual insulin is available to prevent excessive lypolysis and ketonemia. As with DKA, treatment consists of fluid and insulin administration.

Management of the diabetic dental patient

Dental management of the diabetic patient is grounded in an understanding of the patient's diabetic health history. Important historical information includes details of the current diabetic regimen as well as an assessment of the adequacy of blood sugar control. As blood sugar control has profound effects on the morbidity of DM, inquiring about the latest HbA_{1c} value provides useful information regarding the adequacy of plasma glucose control. Other important historical information includes the status of the complications of diabetic retinopathy and nephropathy. Historical information regarding the comorbidities of hypertension, obesity, lipid disorders, and smoking are very important because of their role in the development of cardiovascular disease. For example, the knowledge that a diabetic is at risk for coronary artery disease should have important practical management implications. Specifically, measures to decrease myocardial oxygen demand should include steps to reduce stress, and elevate endogenous catecholamines through the use of sedation techniques, and, as much as possible, a reduction in the administration of catecholamines.

Because of the heightened risk of periodontal disease in DM, preventive periodontal therapy is an important component in the comprehensive dental management of the diabetic patient. Therapy should include careful assessment of a patient's periodontal status followed by explicit, ongoing hygiene instruction, frequent prophylaxis, and monitoring of periodontal health.

Dental appointment scheduling should take into account the importance of nutritional consistency and the avoidance of appointments that will overlap with or prevent scheduled meals. This is particularly important in patients receiving insulin, sulfonylurea, or meglitinide oral therapy because of the risk of hypoglycemia. If an appointment is likely to lead to a delayed or missed meal, the diabetic regimen may have to be modified with the assistance of the patient's diabetologist.

Scheduling of elective surgical procedures must take into consideration not only the anesthetic needs of the diabetic, but the impact that the surgical procedure may have on the patient's ability to consume an appropriate diet.

If, for example, a diabetic patient must fast in preparation for parenteral anesthesia, the diabetic regimen must be modified accordingly to minimize the risk of perioperative hypoglycemia. Intraoperative hypoglycemia especially must be avoided because the signs and symptoms of hypoglycemia may be masked by the parenteral anesthetic technique. For example, in the case of a fasting patient (ie, parenteral sedation) scheduled for a morning surgery, the morning dose of rapid-onset insulin may be reduced or withheld entirely. Similarly, rapid-onset oral agents may be withheld to avoid perioperative hypoglycemia. It is generally advisable to assess the patient's blood glucose both before and after the period when sedation or general anesthesia may mask the presentation of hypoglycemia.

For prolonged procedures, especially if they encroach on mealtime, intraoperative blood glucose evaluation is advisable.

Type-1 diabetics, in particular, may experience episodes of hypoglycemia when there is a relative excess of administered insulin, often from missed or inadequate meals or snacks. Symptoms of hypoglycemia may range from mild—anxiety, sweating, tachycardia, and tremulousness—to severe—mental status changes, seizure, and coma. The early symptoms of hypoglycemia can be accounted for by epinephrine and glucagon release in response to hypoglycemia. The serum glucose threshold for release of epinephrine and glucagon may decrease with time, degrading this important response to hypoglycemia [63]. Such ''hypoglycemic unawareness'' may present with mental status changes without a prodrome of symptomatic increased autonomic activity (eg, sweating, tachycardia). Hypoglycemic unawareness is an important element of a diabetic patient's history that should be recognized by the dentist.

Severe hypoglycemia is a medical emergency. Should the dental patient become hypoglycemic, prompt treatment is necessary. Even a few minutes of severe hypoglycemia (serum glucose $<$40–50 mg/dL) can be harmful, possibly causing cardiac arrhythmias and transient cognitive deficits. Early hypoglycemia should be promptly treated with 15 g of oral carbohydrate, equivalent to 6 oz orange juice, 4 oz cola, 3 to 4 teaspoons of table sugar, five Life Savers, or three glucose tablets (Box 2). Chocolate may delay absorption and should be avoided. If the patient is unable to cooperate or swallow, glucagon 1 mg may be administered by subcutaneous or intramuscular injection. This should be followed by oral carbohydrates when the patient is able take them. Side effects of glucagon include nausea, vomiting, and headache. Alternatively, and in the unresponsive diabetic, hypoglycemia should be aggressively corrected with the administration of intravenous dextrose.

The well-controlled diabetic is probably at no greater risk of postoperative infection than is the nondiabetic. Therefore, routine dentoalveolar surgical procedures in well-controlled diabetics (HbA_{1c} $<$8%) do not require prophylactic antibiotics. However, when surgery is necessary in the poorly controlled diabetic, prophylactic antibiotics should be considered. Notwithstanding the importance of the preoperative glucose control, surgery and

Box 2. Hypoglycemia

Signs and symptoms
Mild
- Anxiety
- Tachycardia
- Sweating

Severe
- Confusion
- Seizures
- Coma
- Cardiac dysrhythmia

Management
Awake or alert patient
- 15 gm carbohydrate (eg, 6 oz orange juice, 4 oz cola, 3–4 teaspoons sugar)

Uncooperative patient
- Glucagon 1 mg subcutaneous or intramuscular injection followed by oral glucose supplement; or dextrose-50 25–50 mL intravenously

Unconscious patient
- Dextrose-50 20–50 mL intravenously

general anesthesia can cause a state of insulin resistance and decreased insulin secretion to the extent that the otherwise well-controlled diabetic may become hyperglycemic in the postoperative period [64,65]. Antibiotics in these situations should be administered pre-operatively and, for procedures longer than 3 to 4 hours, intraoperatively. Finally, delayed alveolar healing following dentoalveolar surgery should raise the dentist's suspicion of osteomyelitis, for which prompt surgical consultation should be arranged.

Summary

Diabetes is a common metabolic disorder associated with glucose intolerance and long-term complications (retinopathy, nephropathy, and neuropathy). Especially in the type-2 diabetic, a clustering of comorbidities (obesity, hypertension, dyslipidemia) not only predisposes to diabetes but, importantly, cardiovascular disease as well. Central to the management of diabetes is the intensive regulation of plasma glucose along with management of comorbidities comprising the "metabolic syndrome." Management of the diabetic dental patient should focus on periodontal health and the delivery

of comprehensive dental care with minimal disruption of metabolic homeostasis and recognition of diabetic comorbidities.

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