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An update in diabetes mellitus

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Abstract

Type I diabetes mellitus, also called insulin-dependent diabetes mellitus or IDDM, is a significant chronic condition with implications for dental treatment. Advances in management include intensified therapy, highly purified insulins, and insulin pumps. Periodontal tissues are affected by IDDM, with resultant increases in disease in children affected with IDDM.

Introduction

Since diabetes has an influence on oral health, it is important for the dentist to be aware of new advances in the field of diabetes and to recognize specific oral problems related to diabetes. The dentist is an important part of the health care team for patients with diabetes.

Recent Concepts and Advances in Diabetes

It is important to understand the differences between the two major categories of patients with diabetes. The most common type of diabetes is Type II or noninsulin dependent diabetes. This is also known as late-onset or maturity-onset diabetes and may affect up to 5% of the population. It usually occurs in patients older than 40, but can occur in individuals as young as teenagers. Most patients are overweight and there is usually a strong family history of Type II diabetes. Weight loss frequently normalizes blood sugar levels. Where weight loss cannot be achieved, patients frequently respond to orally administered hypoglycemic agents, such as chlorpropamide, glipizide, and glyburide. Those who do not respond to oral hypoglycemic agents are treated with insulin. Individuals with Type II diabetes do not become ketotic or develop ketoacidosis, but if not treated become progressively more hyperglycemic. Normal numbers of islet cells are found in the pancreas but the cells are sluggish in producing insulin. The insulin produced is less effective due to insulin resistance, both in peripheral tissues and in the liver (DeFronzo 1988).

Most children with diabetes have Type I, or insulin-dependent diabetes mellitus (IDDM). This was formerly called Juvenile Diabetes; however, this term has now been replaced by Type I diabetes mellitus or IDDM, since approximately 10% of patients have their onset over the age of 21. In the United States, IDDM affects approximately one in 700 children who are 16 years old. Most patients with IDDM are treated with two injections of NPH and regular insulin each day (Table) and measure their blood sugar levels two to three times a day. If one member of the family has IDDM, the likelihood of another member of the family having diabetes is increased, but not nearly to the degree present in Type II diabetes. If one of identical twins develops IDDM fewer than half of the co-twins will develop the disease. In IDDM, beta cells of the islet are destroyed completely by the body's autoimmune system. Recent evidence suggests that this process takes a long time to occur, and most children who develop diabetes have had the process begin at least several years before the actual onset of clinical symptoms. An acute illness may precipitate diabetic symptoms; however, the illness does not cause the diabetes. Children with IDDM are subject to wide variations in their blood sugar levels and prone to both hypoglycemia and ketoacidosis.

Table. Action time of different types of insulin (hours)

	Onset	*Peak*	*Duration*
Regular	1/2	2–3	4–6
NPH or Lente	2–3	6–10	12–18
Ultralente	6–12	none	18–36

Over the past 10 years, the development of the technology for self-blood glucose monitoring and intensive insulin treatment programs has allowed patients to attain near-normal blood glucose levels. Development of techniques for self-blood glucose monitoring has allowed patients with diabetes to accurately measure

their blood glucose level as they participate in their usual activities. After applying a drop of blood to the pad on a strip and waiting a prescribed amount of time (40–60 sec), the resulting color change can be read either by eye against standards provided by the strip manufacturing company, or the strip can be read in a meter. Since the system is portable, patients can test before taking their insulin injections to adjust their regular insulin dose or to document hypoglycemic reactions. In addition, self-blood glucose monitoring is very useful during periods of illness or heavy exercise.

Patients on intensified treatment plans test their blood sugar four or more times a day and take three or four insulin injections a day or wear an insulin pump. An insulin pump infuses a programmable constant infusion of regular insulin and allows injecting boluses of insulin at mealtimes. Tubing from the insulin pump is connected to a needle that rests in the subcutaneous tissues of the abdominal area. Patients on intensified therapy usually try to keep their before-meal blood glucose levels between 80 and 120 mg/dl, and their after-meal glucose levels less than 180 mg/dl. Many lines of laboratory evidence have suggested that high blood glucose levels are important in causing the complications of diabetes that occur in the kidneys, retina, peripheral nerves, and special blood vessels. Currently, a national study, The Diabetes Control and Complications Trial, is underway to test the effect of intensive blood glucose control on the development of diabetic complications. The results of this trial will provide valuable understanding about the risks and benefits of intensified diabetes control. In preliminary data, it is clear that intensified glucose control programs produce a greater incidence of hypoglycemic reactions when compared to conventional therapy.

Current treatment strategies using subcutaneous insulin are handicapped in their efforts to produce normal blood glucose levels. In nondiabetic individuals, insulin secreted by the islet cells of the pancreas enters the portal veins and flows directly to the liver. The liver, clearing one-half of the insulin, produces systemic levels of insulin that are much lower than the portal insulin level. In patients with diabetes, insulin is placed under the skin; this produces systemic and portal levels of insulin that are the same. Therefore, to obtain an adequate portal insulin level the systemic level must be elevated. This increases peripheral glucose utilization and therefore the risk of hypoglycemia. Also, the rate of absorption of subcutaneously injected insulin depends on the type of insulin (regular, lente, NPH, ultralente) and subcutaneous blood flow. With a functioning pancreas, the blood glucose level is sensed and the correct amount of insulin secreted.

Much research has been devoted to developing ways of treating diabetes that avoid the difficulties inherent in the current methods of treatment. Pancreatic transplantation, utilizing a cadaver pancreas or part of a living donor's pancreas, is the most efficacious treatment available (Mauer et al. 1989). During this procedure, the pancreatic graft is transplanted into the abdomen. Because pancreas transplants are foreign tissue, they require continuous immunosuppression to continue to function. The serious toxicity of immunosuppressing medications requires restricting most pancreas transplants to patients who have had renal transplants for kidney failure and, therefore, need immunosuppressing drugs to prevent kidney rejection. Research also has been directed to transplanting islet cells isolated from fetal or adult pancreases. These methods work well in genetically identical animals but have been largely unsuccessful in humans due to the potency of the body's immune system. With the development of effective but less toxic immunosuppressive agents, success may be achievable.

An "artificial pancreas" that would function like current insulin pumps but with an attached blood glucose sensor to determine the glucose and automatically adjust the insulin dose appropriately, has long been a dream of people with diabetes. Unfortunately, the development of an implantable glucose sensor which will work for an extended period of time has not been successful.

One recent advance that has helped all people who need to take insulin is the availability of highly purified insulins. Initially, insulin was prepared from beef and pork pancreases and, as recently as the 1960s, contained a large amount of impurities. In the 1970s, highly purified insulin of porcine origin was developed. These insulins greatly reduced the frequency of local allergic reactions to insulin. In the past five years, human insulin has become widely available. Human insulin is made either by recombinant DNA technology, or by starting with pork insulin and changing the one amino acid different from human insulin. Allergic reactions to human insulin are rare and most patients take human insulin without problems.

Measurement of blood glycosylated hemoglobin offers an assessment of success at control of blood glucose levels and allows identification of patients in whom blood glucose control is poor. The test is a measurement of the average blood glucose level over the previous 1–2 months. It takes advantage of the fact that glucose irreversibly attaches to hemoglobin molecules by a reaction whose rate is dependent on the blood glucose level. Thus, the higher the blood glucose level, the more glycosylated hemoglobin formed. Several different types of tests are available including total glycosylated hemoglobin, hemoglobin A1c, and hemoglobin A1. These measure different populations of glycosylated hemo-

globin molecules, and all are valid as long as results are compared to the normal range for each test.

Recent interest has been generated by some early success reported in treating insulin-dependent diabetics with immunosuppressive agents at the time of diagnosis. Initially, studies showed that cyclosporine could preserve insulin secretion ability in a significant percentage of new onset Type I diabetics (Bougneres 1988). Unfortunately, the cyclosporine had to be continued for the effect to remain, and only about a third of the patients had a really dramatic effect. As patients remained on the medication for longer periods of time, toxicities developed from cyclosporine and its use in patients with new onset IDDM has stopped. Hopefully less toxic immunosuppressive agents can be developed which will suppress the autoimmune reaction that is destroying the islet cells without toxic side effects.

Dental Problems in Patients With Diabetes

Multiple studies have evaluated the dental status of children in young adults with insulin-dependent diabetes. The frequency of caries is not increased in children with diabetes. There has even been some suggestion that the frequency of caries may be decreased and this might be attributed to the decreased free sugar intake characteristic of the diabetic diet.

In contrast to the lack of increase in caries in patients with diabetes, there is a marked increase in the prevalence and severity of periodontal disease in patients with diabetes.

In a study investigating periodontal disease in adults with diabetes (mean age 47 years) Bacic´ et al. (1988) found no differences in the frequency of pathologic periodontal pockets between the patients with diabetes and the control group up to age 34; however, in the older patients, deep periodontal pockets were more frequent in the patients with diabetes. Their patients included subjects with both Type I and Type II diabetes and they did not find any difference in periodontal disease between the two groups.

In the study by Faulconbridge et al. (1981) 94 diabetic children between the ages of 5–17 were matched by gender and age to children without diabetes. There was no difference in the frequency of dental caries. However, the periodontal disease score and plaque score were significantly higher in both the male and female patients with diabetes. Analysis of saliva revealed that the patients with diabetes had the same pH as the control subjects but had a higher level of glucose (0.62 vs. 0.12 mmol/L). The authors did not have a measure of diabetic control so the results could not be related to degree of blood sugar control.

Cianciola et al. (1982) studied the incidence of periodontitis in 186 children with diabetes and compared the results to both sibling controls and unrelated control patients who did not have diabetes. They found no periodontal disease in any of the patients under 10 years old, whether or not they had diabetes. In patients 11–18 years old, 9.8% of the patients with diabetes had detectable periodontitis, while this was present in only 1.7% of the control patients. Among the patients with diabetes, the frequency and severity of periodontitis increased with age. The duration of diabetes also increased the likelihood of a patient having periodontal disease. Surprisingly, despite the increase in gingivitis and periodontitis, the plaque index was not increased in patients with diabetes. This suggests that factors other than plaque accumulation may be responsible for the increased frequency and severity of periodontal disease in diabetics. In all the patients, periodontitis was asymptomatic and not identified until the patients participated in the study.

Several studies have used glycosylated hemoglobin measurements to relate periodontal disease to the degree of blood glucose control. In a Swedish study, 21 children with diabetes who were in poor metabolic control were compared with 22 children with diabetes who were in good metabolic control and with 23 age-matched controls (Gislen et al. 1980). For the children with the highest amount of bacterial plaque, the children with diabetes had higher gingival inflammation scores. In the children with diabetes who had poor metabolic control, there was a tendency toward an increase in gingival inflammation. There was little difference between the patients with diabetes in good control and subjects who did not have diabetes.

Harrison and Bowen (1987) investigated the relationship of dental problems to the degree of metabolic control in children aged 4–19 years with IDDM. The patients were classified into groups of poor or good diabetic control based on the level of their glycosylated hemoglobin. The poorly controlled patients with diabetes had the same DMFS scores as the well-controlled patients with diabetes and the control group without diabetes. The poorly controlled patients with diabetes had a higher mean plaque score and gingival index than both those with well-controlled diabetes and the control group. This study is important because several previous studies did not find a difference in plaque index between diabetic and healthy children. However, in these studies the children with diabetes were not classified by degree of control. We speculate that our findings of increased plaque may be due to either decreased salivary flow in poorly controlled patients with diabetes or due to the elevated salivary glucose concentration in poorly controlled patients with diabetes. It also is possible that oral hygiene practices may have been different between the two groups.

Finestone and Boorujy (1967) evaluated 189 patients with diabetes and 64 control patients for periodontal disease. The frequency and severity of periodontal disease was increased in the patients with diabetes and was increased the longer the duration of the diabetes. Both Type 1 and Type 2 diabetic patients apparently were included in the study population.

Because of the recognition that bacterial flora are important determinants of periodontal disease and with the identification of *Actinobacillus actinomycetemcomitans* as a causative agent of localized juvenile periodontitis, interest has been directed to the subgingival flora in patients with insulin-dependent diabetes. Mashimo et al. (1982) studied 14 patients ranging from 13 to 27 years old. They displayed a wide range of periodontal disease from no disease to severe alveolar bone loss. A. actinomycetemcomitans was detected in three of the nine patients with diabetes with periodontitis and in none of the other patients with diabetes. The organism most frequently cultured from the patients with periodontal disease was Capnocytophaga. This organism also is found in patients with localized juvenile periodontitis. Since patients with localized juvenile periodontitis are thought to have a defect in neutrophil function (Genco et al. 1986), and since hyperglycemia can produce neutrophil dysfunction, it is tempting to speculate that the abnormal flora present in diabetics with periodontal disease is due to chronic hyperglycemia affecting neutrophil function.

Management of Patients With Diabetes During Dental Procedures

For dental procedures requiring no anesthesia or local anesthesia, adjustments in the insulin plan usually are not needed. If patients are not able to chew after the procedure, they can ingest calories in the form of a milk shake or other liquids. If hypoglycemia develops during the procedure, the procedure should be stopped, and if the patients have self-blood glucose testing materials with them, a blood test should be done. If the blood test confirms a low sugar level or if no testing supplies are available, the patients should be treated for hypoglycemia. Most Type I diabetics carry a source of rapidly acting carbohydrate with them. If the patients do not have any carbohydrate, sugar packets, orange juice, candy bars, or any other source of rapid-acting carbohydrate can be used.

If general anesthesia is to be used and fasting is required, adjustments must be made in the insulin treatment plan. If patients need to fast after midnight, they should have a larger than usual bedtime snack and also may require a decrease in their before-dinner NPH dose on the day before surgery. Surgery should be scheduled early in the morning and the morning insulin dose postponed until after surgery is completed and the patient is able to resume liquid intake. Self-blood glucose monitoring can be used to monitor the level of blood glucose, and supplementary insulin or carbohydrate should be given as needed.

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