To Compare the Efficacy of Plasma Glucose Level, Finger Capillary Blood, and Gingival Crevicular Blood to Measure Blood Glucose Level in Chronic Periodontitis Patients

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Abstract

Background: A high number of patients with Periodontitis may have undiagnosed diabetes mellitus (DM). Diabetes is an associated risk factor for chronic periodontitis and has several other oral symptoms including dry mouth and oral infection. Expanding the role of the dentist may prove to be an efficient method of early detection and management of diabetes. Aim: The purpose of the present study was to evaluate whether blood oozing from gingival crevice during routine periodontal examination can be used for determining glucose levels. Materials and Methods: A total of 120 male/female patients with Chronic Periodontitis in the age group of 30 years and above were selected and divided into three groups i.e. Control Group (Plasma glucose level), Test Group 1 (Finger capillary blood) and Test Group 2 (Gingival crevicular blood). Blood glucose measurements were made using gingival crevicular blood and finger capillary blood using glucose self monitoring device (Accu-Chek Active) and at the same time venous blood was collected for measurement of serum (plasma) glucose. Data obtained were statistically analyzed using Paired t-test (p), and Pearson’s correlation test (r). Results: The results revealed a strong correlation between (a) gingival crevicular blood and finger capillary blood (r = 0.999; P < 0.133); and also (b) between GCB and Plasma glucose level (r = 0.984; P < 0.230). Conclusion: The data from this study has shown that gingival crevicular blood collected during diagnostic periodontal examination can be an excellent source of blood for glucometric analysis. GCB can be used as a marker for blood glucose estimation using glucometer. The technique described is safe, easy to perform and helps to increase the frequency of diabetes screening in dental office.

Keywords: Chronic periodontitis, diabetes mellitus, finger capillary blood, gingival crevicular blood, plasma glucose level

INTRODUCTION

Periodontal disease is a multifactorial chronic inflammatory oral disease affecting 10%–15% of the general population worldwide.[1] Its advanced form is characterized by periodontal ligament loss and destruction of the surrounding alveolar bone.[2] It is the main cause of tooth loss and is considered one of the two biggest threats to the oral health.[2,3] It is initiated and perpetuated by microorganisms such as Porphyromonas gingivalis which exist as complex biofilms on the tooth surface. The infection affects the tissues of the periodontium and if left untreated can lead to severe destruction of the connective tissues and the bone supporting the tooth.[4] The relationship between periodontal disease and systemic disease has been underlined in dentistry and human medicine, importance of the dentists examining the patient’s mouth, and obtaining a complete medical history of the patient.[5] Significant associations between periodontal disease and diabetes mellitus (DM), cardiovascular disease, preterm low birth weight, and osteoporosis have been discovered, bridging the once-wide gap between medicine and dentistry.[6] The dentist and physician must consult and work together to provide optimal health care for the patient. The synergism between systemic diseases and periodontitis patients has been demonstrated by researchers from many countries since many decades. Brasher and Rees reported 47.3%,[7] Peacock and Carson reported 52.5%,[8] Lagervall et al. reported 49.4%,[9] Georgiou et al. stated 60%, Dumitrescu reported 81.96%[10] and in a study by Zainoddin reported that 30.5%[11] periodontal disease patients had some
One of the major public health problems faced by the society today is DM. There has been a widespread increase in the number of DM patients globally, and in India, it has been exorbitantly increasing. With the number of 31.7 million people, India has been ranked first with diabetes in the year 2000,[12] and in 2015, India was called the diabetes capital with home to 69.1 million people with DM, the second highest number of cases after China. Recently, in a Diabetes atlas published by the International Diabetes Federation, it was estimated that in 2017, there were 451 million (age 18–99 years) people with diabetes worldwide. These figures are expected to increase to 693 million by 2045.[13]

In 1998, the World Health Organization[14] adopted the diagnostic parameters for diabetes established by the American Diabetes Association. The current gold standard for diabetes screening is measuring the fasting blood glucose. However, there are some issues about using fasting blood sugar such as keeping the patients fasting for about 8 h and not being applicable afternoon. Not only these laboratory methods are time-consuming and invasive, they require elaborate equipment also.[15] Since a long time, venous blood or urine samples are being sent to clinical biochemistry laboratories by the clinician for determining glucose levels. Nowadays, frequent monitoring of blood glucose has been recommended for use in the management of individuals with diabetes. It has also been shown that the portable blood glucose monitors typically utilized by these individuals can be very effective in the management of blood glucose both as a bedside in the hospitals and also for home testing. The results of these portable blood glucose monitors are obtained instantaneously as compared to the laboratory methods, which helps the clinician to decide if further confirmatory tests are required to diagnose diabetes.[16] Recently, there has been an increasing evidence of research carried out to use gingival crevicular blood (GCB) in monitoring blood glucose levels.[17] The glucometer device may allow noninvasive or minimally invasive monitoring of blood glucose from oozing blood from the gingival crevice of patients with periodontal disease during the routine periodontal examination. Even in the case of low gingival crevicular bleeding, a glucose measurement is possible with the use of glucose self-monitoring device, due to the low amount of blood (3 µl) necessary to perform analysis. Not only this technique is less traumatic to the patient but also simple and relatively inexpensive in-office screening device for any patient suspected to have diabetes. They can also be used to monitor blood glucose levels in known diabetic patients.[18] And also, early detection of diabetes would help the periodontists in patient education, motivation, and possible prevention of periodontitis. Furthermore, there is a greater likelihood of a favorable prognosis of periodontitis when diabetes is discovered in the early stages.

This present study was indented to compare the efficacy of plasma glucose level (PGL), finger capillary blood (FCB) and GCB to measure blood glucose level in chronic periodontitis patients. The blood glucose monitoring system used in the study is ACCU-CHEK Active, Roche Diagnostics, USA, which works on the principle of electrochemical methodologies.

The objectives of the study are:
1. To assess the reliability of glucose self-monitoring device in measuring GCB, FCB, and its comparison with PGL
2. To evaluate the blood glucose level of GCB from maxillary anterior and mandibular anterior teeth using self-monitoring device.

**Materials and Methods**

The study was carried out in the Department of Periodontology of a Dental College. Ethical clearance was obtained for the study and written consent was obtained from every patient before performing the tests. A total of 120 male/female patients with chronic periodontitis in the age group of 30 years and above were taken for the study. They were divided equally in three groups, PGL being the control group, whereas FCB and GCB constituted the test Groups 1 and 2, respectively. Patients who were willing to undergo surgical therapy, if required, for periodontitis were only included.

**Inclusion criteria**
1. Patients diagnosed with chronic periodontitis
2. Patient gives informed consent to participate in the study
3. Patient has at least 20 remaining teeth in both the jaws
4. Patients with pocket depth ≥4 mm were considered in the study.

**Exclusion criteria**
1. Patients having bleeding disorders
2. Any medication interfering with the coagulation system
3. Patients undergoing treatment for anemia, polycythemia, gout, dialysis, or any other disorder that can cause an abnormal variation in the hematocrit.

**Data collection**

The record of the patients was maintained as per the pro forma to have a systematic and methodical recording of all the information and observations. The intraoral clinical examination was done in a dental chair, under standard conditions of light, using a mouth mirror, explorer, UNC-15 Periodontal probe (Hu-Friedy®, USA) and tweezers. Clinical parameters such as clinical attachment levels, periodontal pocket depth, and Sulcus Bleeding Index (Mühlemann and Son 1971) were recorded by a single examiner.

The patients considered in the study presented the following criteria: (a) diagnosis of advanced periodontal disease based on Armitage,[19] (b) probing depth ≥4 mm, and clinical attachment loss ≥3 mm. Clinical attachment level was recorded from the cementoenamel junction to the base of the pocket using
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UNC-15 Periodontal Probe (Hu-friedy®, USA). Periodontal pocket depth was measured as the distance from the gingival margin to the bottom of the gingival sulcus. Gingival inflammation was determined with the help of Gingival Index given by Mühlemann and Son.[20]

Glucose measurement

Plasma glucose level

A tourniquet was tied around the patient’s arm about 3” to 4” (7.5 cm to 10 cm) above the venipuncture site. The vein was tapped with index finger to encourage dilation. The area was disinfected with an alcohol wipe in a circular motion. Venous blood sample was drawn from patient’s antecubital fossa for measurement of serum (plasma) glucose. Samples were collected by the trained technician from the laboratory of SGT Hospital, Gurgaon [Figure 1].

Finger capillary blood

Surgical spirit was wiped on the fingertip of the fourth finger and was allowed to dry and then punctured using a disposable sterile. The first drop of blood was discarded and the second drop was used. This may reduce the risk of an inaccurate result. The test strip was inserted into the test port of glucometer with contact bars end first and facing up. The test strip was pushed in until a resistance was felt. The meter then turned on automatically, and the display check appeared briefly.

This was followed by the symbol of blinking drop on the monitor suggesting that the device was ready for the test. Capillary blood sample from the finger was then drawn onto the test strip. It was held until the instrument gave a beep displaying the blood glucose measurements on the screen in mg/dl and FCB readings were recorded [Figure 2].

Gingival crevicular blood

The GCB (80 from maxillary anterior and 40 from mandibular anterior) were taken for estimation of blood glucose levels. For each measurement, site with profuse bleeding on probing (BOP) was chosen. Patients were asked to rinse with chlorhexidine mouthwash before the collection of GCB. The most inflamed site from anterior teeth in each patient was selected and contamination with saliva was prevented using cotton rolls and air drying. Bleeding was induced by UNC-15 periodontal probe (Hu-Friedy®, USA) until a sufficient quantity of blood (2–3 µl) was collected by insulin syringe. The glucometer monitoring device was loaded with the active test strip. The blood drop from syringe was transported to test strip of glucometer. It was held until the instrument gave a beep displaying the blood glucose measurements on the screen in mg/dl and GCB readings were recorded [Figure 3a and b].

Statistical analysis

Data were analyzed using SPSS IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. and MS EXCEL 2007. Tests performed were Descriptive statistics, Paired t-test for intragroup comparisons and Pearson’s correlation (r) was done to know the correlation between the three groups. Descriptive statistics included mean ± standard deviation (SD) of the scale data and its measurements.

Results

The study included a total of 120 chronic periodontitis patients (79 [66%] males and 41 [34%] females), in the age
group of 30 years and above. The participants were divided into three groups as Control Group (PGL), Test Group 1 (FCB), and Test Group 2 (GCB).

Table 1 summarizes the mean and SD of blood glucose measurements between Test Group 1 (125.58 ± 59.77) and Control Group (108.26 ± 27.75), Test Group 2 (114.71 ± 51.71) and Control Group (108.26 ± 27.75), and Test Group 1 (125.58 ± 59.77) and Test Group 2 (114.71 ± 51.71). A comparison was made between blood glucose measurements of Test Group 1 and Control Group showing a high mean value of Test Group 1 (125.58 mg/dl) followed by Control Group with mean value (108.26 mg/dl) showing a $P < 0.05$, thus giving statistically significant results. A comparison between blood glucose measurements of Test Group 2 and Control Group with a $P = 0.230$ and comparison between Test Group 1 and Test Group 2 showed $P = 0.133$, thus giving statistically nonsignificant results, respectively.

**Correlative relationships**

Table 2 shows Karl Pearson’s product–moment correlation ($r$) for Control Group, Test Group 1, and Test Group 2. A value of correlation coefficient close to ±1 was considered as a strong positive linear relationship (i.e., one variable increases as the other) and a value close to −1 was considered as a strong negative linear relationship (i.e., one variable decreases as the other increases), and a value close to 0 was considered as no linear relationship. The $r$ value between Control Group and Test Group 1 was 0.985, between Control Group and Test Group 2 was 0.984, and between Test Group 1 and 2 was 0.999 and it shows a strongly positive correlation.

**Discussion**

Periodontal diseases are collectively the most common diseases known to the humankind. Its treatment is a long-term process which persists for years, a single blood glucose test would not be sufficient for periodontal management and moreover routine blood glucose test can be yielded by consultation with a diabetic physician. As per Collin et al. (1998), advanced periodontitis is seen to be associated with the impairment of the metabolic control in noninsulin-dependent DM and therefore requiring a regular periodontal surveillance.[21] Hence, the multiple measurements of the blood glucose levels in a patient would help the periodontist assess the patient’s diabetic control during the treatment progression.

The present study was designed to compare the efficacy of PGL, FCB, and GCB in chronic periodontitis patients. Plasma glucose measurement with the highest level of diagnostic accuracy is known as the “Gold Standard” and its comparison to the other two methods is necessary to assess the correctness of each blood collecting technique and device. Since the glucose self-monitoring device and laboratory tests do not measure the same components, the reported figures are likely to vary between methods. Laboratory tests generally test plasma, but a glucose self-monitoring device uses whole blood. As a result, if both tests are taken at the exact same time, the self-monitoring device is likely to show a lower figure than the laboratory results. The new standard method has to prove sufficient agreement with the “gold standard” as mentioned earlier,[22] but the GCB and FCB was not compared to plasma glucose measurements in neither of their studies.[22,23]

Comparing the measurements of FCB with GCB is correct but not sufficient and the amount of disagreement between with GCB measurements and laboratory-measured plasma glucose is essential for drawing a definitive conclusion, although any new method cannot be measured completely without error. This comparison using laboratory measured plasma glucose was not done in the previous studies except the study of Parker et al., who have investigated the correlation of finger stick and crevicular gingival blood with whole blood glucose, measured in a laboratory analyzer.[24]

On comparing GCB and PGL and GCB and FCB, $P$ value was found to be 0.230 and 0.133, which were statistically nonsignificant, whereas on the comparison of PGL and FCB, the results were found to be statistically significant ($P = 0.004$). This was in accordance with the study conducted by Boyd et al.[25]

Stein and Nebbia in 1969[24] were the first to describe a chair-side method of diabetic screening with gingival blood in which blood was wiped directly from the hemorrhagic gingival tissue and transferred onto the test strip for testing. Tsutsui et al.[27] reported the rubbing of blood onto the test strip from a blood-laden dental curette. However, there were few downsides to this technique. A uniform time reaction was not produced when blood-laden dental curette was rubbed or directly wiped on to the test strip which further damaged the strip’s chemical
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indicator surface. A consensus statement by the American Diabetes Association in 1978[28] said that the main sources of error while using glucose monitors are manual timing of the test strip reaction and the wiping of the test strip. Stein and Nebbia (1969) to more recent studies of Beikler et al.[29] and Khader et al.[30] attempted to prove that extravasated blood from the gingival crevice due to inflammation can provide an acceptable source for measuring blood glucose in diabetic patients. Yamaguchi et al.[31] have investigated a method for noninvasive blood glucose measurement using the gingival crevicular fluid, entailing the use of a high sensitivity glucose testing tape to evaluate the possibility of using this fluid for noninvasive blood glucose measurement, and concluded that gingival crevicular fluid could be used as a method of blood glucose measurement.

The sampling procedure used in this study was much easier to perform and less time-consuming and required no additional tools to collect GCB (insulin syringe). The most inflamed sites of maxillary/mandibular anterior region were chosen for glucose measurements as they offer ideal access for GCB. Bleeding gingival site was isolated with a cotton roll after scaling and then rapidly sampling blood with an insulin syringe was an improvement over the past studies. The use of insulin syringe might not eliminate contamination, but it does reduce saliva, plaque, and debris by collecting free-flowing blood just inside the gingival crevice. In contrast to our study, Parker et al.[32] used plastic pipette which is claimed to reduce contamination of the sample with saliva, plaque, and debris followed by Prabhu et al.[33] using capillary tube for sample collection.

ACCU-CHEK Active, Roche Diagnostics, USA (second-generation glucometer) used in the study offers advantage over the first-generation glucometer, as it needs a larger blood sample, that is, about 10–15 μl and the blood sample has to be placed on the test strips to be wiped off later by the user after a certain time interval. Thus, it gives a reading by color matching. It also offers advantage over the third-generation glucometer which is a noninvasive meter and the samples are obtained without direct contact with the body tissues.[33] Hence, its use for detecting the glucose readings with the GCB sample may not be possible. Measuring blood glucose with a second-generation glucometer is very sensitive since it can provide results within 10 s. It is less time-consuming procedure since no sophisticated armamentariums are necessary to collect GCB. Even in case of very low gingival crevicular bleeding, measurement of blood glucose is possible with the use of self-monitoring glucometer, as a very minimum amount of blood (3 μl) is required to perform the analysis. The present study reiterates with the studies done by Partheeban et al.[34] Pennmetsa et al.[21] and Patil and Kamalakannan.[35]

According to our findings, Pearson’s correlation coefficient between Test Group 1 and Control Group, Test Group 2 and Control Group, and Test Group 1 and 2 is highly significant and shows a positive correlation (r) of 0.985, 0.984, and 0.999, respectively. The finding of the present study is consistent with most of the previous studies of Wu et al.[36] Ardakani et al.[37] Shetty et al.[38] and Strauss et al.[39] In these studies, it was reported that GCB samples are acceptable to screen for diabetic patients with sufficient BOP, in which samples can be obtained easily as they do not require touching of the tooth or the gingival margin as periodontal inflammation with or without complicating factor of DM is known to produce ample extravasated blood during diagnostic procedures.[40] Furthermore, the modulus by which the sulcular blood is collected is critical because the resultant glucose values may be altered if there is any contamination of the collected sample by the oral tissues or tissue products.

In our study, sample collection of the crevicular blood was done from the capillaries on the outer surface of the gingiva, which eliminated any possibility of contamination with crevicular fluid. None of the patients under study reported pain or discomfort and no complications have been reported after sampling by this method. This method cannot be applied in cases where purulent exudates are found in pockets. This results in dilution of the blood sample and alteration of glucose levels.

**Conclusion**

The glucometer is a safer, convenient, quick, and inexpensive apparatus that can be used as a chair-side aid during the routine periodontal examination to screen blood glucose. The self-monitoring blood glucometer should not be used to replace the conventional blood glucose measurement method which is still considered to be the gold standard. The result of the present study suggests that the GCB expressed during routine periodontal examination can be used to screen for diabetes. GCB glucose estimation through glucometer during routine periodontal examination is noninvasive, less time-consuming, and therefore, helps to increase the frequency of diagnosing diabetes in dental office and provides a more objective indicator for referral to physician than traditional methods. Thus, the dentist may increase his importance as member of the health team by participating in the search for undiagnosed asymptomatic DM.

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**Conflicts of interest**

There are no conflicts of interest.

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