Evaluation of Gingival Blood as a Minimally Invasive Screening Tool for Diabetes Mellitus among 40–59-year-old Adults in Dental Clinics: A Cross-sectional Study

Abstract

Objective: To evaluate a quick, safe, and minimally invasive method to screen for diabetes mellitus by using gingival blood with the help of self-monitoring glucometer during periodontal examination.

Materials and Methods: A hospital–based, cross-sectional comparative study was conducted among 40–59-year-old diabetic and nondiabetic patients who had come for their master health examination to a private tertiary care hospital (Global Hospital and Health City) in Chennai. Among them, those who fulfilled the inclusion criteria were selected for the study. Thirty diabetic and thirty nondiabetic patients with moderate to severe gingivitis were enrolled and subjected to routine clinical periodontal examination. Blood samples of two sites were analyzed using a glucose self-monitoring device (Accu-Check). Patients were tested for venous fasting blood sugar (VFBS), venous postprandial blood sugar (VPPS), gingival fasting blood sugar (GFBS) level, gingival postprandial blood sugar (GPPS) level, peripheral fingerstick fasting blood sugar (PFBS) level, and peripheral fingerstick postprandial sugar (PPPS) level. Data obtained were statistically analyzed using Student’s t-test, ANOVA, and Pearson’s correlation test. Results: A significant positive correlation was found between GFBS and VPPS, GFBS and PFBS, GPPS and VPPS, and GPPS and PPPS (P < 0.01) in both diabetic and nondiabetic patients correlation. Using venous blood glucose level as a gold standard, the sensitivity and specificity of GFBS was 93% and 100%, respectively, whereas in GPPS, the sensitivity and specificity was 80% and 96%, respectively. Conclusion: Gingival blood glucometry can be used as a minimally invasive screening tool for diabetes mellitus in dental clinics.

Keywords: Diabetes mellitus, gingival blood glucose, gingival glucometry, minimally-invasive, periodontitis

Introduction

Diabetes mellitus represents one of the major chronic health problems faced by society causing major burden upon health-care facilities in all countries. The incidence of diabetes mellitus all over the world, especially in India, is on a steep rise.[1] Globally, diabetes caused 4.6 million deaths in 2011, and health-care expenditure attributed to diabetes was estimated to be at least 465 billion US dollars or 11% of total health-care expenditure. It is predicted that by 2030, diabetes mellitus may afflict up to 100 million people in India and 552 million globally.[2] As of June 2015, 50.8 million people are suffering from diabetes in India.[3] Diabetes and periodontitis seem to interact in a bidirectional manner.[4] The increased prevalence and severity of periodontitis seen in patients with diabetes, especially in those with poor metabolic control, has led to the designation of periodontal disease as the “sixth complication of diabetes.”[5–7] Hence, successful periodontal therapy in patients with diabetes entails the stabilization of blood glucose to a normal range.[5,8] Because of the association between dental infections and diabetes mellitus, dentists are likely to encounter an increased number of undiagnosed diabetic patients. Oozing blood from the gingival crevice during periodontal probing may allow minimally invasive monitoring of blood glucose. Hence, this study was designed to evaluate a quick, safe, and minimally invasive method to screen for diabetes during regular periodontal examination using self-monitoring glucometer.

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Materials and Methods

A comparative study among sixty patients was conducted at a tertiary care hospital (Global Hospital and Health City) in Chennai among 40–59-year-old study participants. The proposed study was reviewed by the Ethical Committee of both the Institutions (MAHER and Global Hospital and Health City), and clearance was obtained. Informed consent was obtained from each participant before conducting the trail. The study was carried out for the duration of 1 month from June to July 2015. The inclusion criteria included individuals who were aged 40–59 years, whose venous blood (VB) glucose level tested on the same day for diagnosis of diabetes mellitus whose Fasting Plasma Glucose level 112.6 mg/dl which is gold standard for screening diabetes, and individuals with moderate to severe gingivitis and who were newly diagnosed as diabetic patients. The exclusion criteria included individuals undergoing treatment for anemia, polycythemia, gout, dialysis, or any other disorder that could cause an abnormal variation in the hematocrit and with any requirement of antibiotic premedication. In addition, individuals on medication that can interfere with coagulation-supplemental Vitamin C that could interfere with the glucose test strip oxidation reaction, individuals with history of any systemic diseases, and individuals who were previously diagnosed as diabetic and under medications for diabetes to avoid confounding bias were also excluded from the study. Based on the results of the pilot study conducted among ten diabetic and ten nondiabetic study participants, sample size determination was calculated using sampling Software G Power 3.1.9.2. (Heinrich-Heine-Universitat Dusseldorf, Germany). With an effect size of 0.525, α error 0.05 and power of the study kept at 90%, the required sample size was 30 per group, a total of 60 study participants.

Methodology

Patients were identified as diabetic and nondiabetic individuals on the basis of VB glucose level. VB glucose level was estimated using glucose oxidase and peroxidase method with automated chemical analyzer from 2 ml of blood drawn from the left antecubital vein. Gingival index (Loe H and Silness J 1963) was recorded on these patients to select the study participants with moderate to severe gingivitis and individuals with periodontitis were avoided (we have taken into account gingival status rather than periodontal status because diagnosing patients with diabetes mellitus in gingivitis itself gives us a chance of early primary intervention). Supra- and Subgingival scaling was done to facilitate collection of the blood. Bleeding on probing was assessed after 30–60 s. Sites with profuse bleeding were preferred as donor sites and sites with suppurations were avoided. To obtain a clean sample, probing was repeated when necessary until a sufficient quantity of blood was collected to gather a sample. The blood obtained from the gingival bleeding was transferred to a test strip preloaded in a self-monitoring glucometer (Accu-Chek Active, Roche Diagnostics, USA) which will report blood glucose measurements in mg/dl within 15–30 s. The regular peripheral finger stick blood was collected from patient’s fingers by wiping the pad of the finger with alcohol, allowing it to dry and then punctured with a sterile lancet. The blood was drawn onto the test strip preloaded in the glucometer. Both samples from each individual were taken at the same visit. Patients were asked to have their breakfast and report back after 2 h. The entire procedure was repeated to record the venous postprandial blood glucose level, gingival postprandial blood glucose level, and peripheral finger stick postprandial blood glucose level.

Statistical analysis

Statistical Analysis was carried out using SPSS Software version 16 (IBM Corp., Chicago, IL, USA). Normality of quantitative data collected was assessed using Shapiro–Wilk test and was found to be parametric in nature ($P > 0.05$). Comparison of all the six parameters (venous fasting blood sugar [VFBS], venous postprandial blood sugar [VPBS], gingival fasting blood sugar [GFBS], gingival postprandial blood sugar [GPPS], peripheral fingerstick fasting blood sugar [PFBS], and peripheral fingerstick postprandial blood sugar [PPBS]) between diabetic and nondiabetic group was carried out using independent Student’s $t$-test. Comparison of fasting (GVBS, VFBS, and PFBS) and postprandial (GPBS, VPBS, and PPBS) from various sites was carried out using one-way ANOVA for both diabetic and nondiabetic group separately. Correlation of VFBS, PFBS with GFBS and also VPBS, PPBS with GPBS was carried out using Pearson’s correlation test in both diabetic and nondiabetic group. $P < 0.05$ was considered statistically significant in this study.

Results

Among sixty study participants examined, 60% (18) were male and 40% (12) were female in diabetic and 50% (15) were male and 50% (15) were female in nondiabetic group. No significant difference was found in the distribution of gender between the groups ($P > 0.05$). The mean age of males was 52.6 ± 3.9 and 52.9 ± 5.2 in diabetic and nondiabetic group, respectively. The mean age of females was 50.8 ± 3.7 and 51.5 ± 5.0 in diabetic and nondiabetic group, respectively. No significant difference was found in the distribution of age between the groups ($P > 0.05$). Twenty-two (73.3%) and 21 (70%) individuals belonged to upper class and 8 (26.7%) and 9 (30%) belonged to upper middle class in diabetic and nondiabetic group, respectively. No significant difference was found between the groups ($P > 0.05$) [Table 1].

When all the six parameters (GFBS, GPPS, PFBS, PPBS, VFBS, and VPBS) were compared between diabetic and nondiabetic group, the difference found between the groups
was very highly statistically significant \((P = 0.000)\) [Table 2 and Graphs 1 and 2].

**Diabetic group**

Among thirty diabetics, no significant difference was observed between fasting blood glucose levels (GFBS, VFBs, and PFBS) \((P > 0.05)\) [Table 3 and Graphs 3 and 4]. No significant difference was observed between postprandial blood glucose levels (GPPS, VPPS, and PPS) \((P > 0.05)\) [Table 3, Graphs 5 and 6]. No significant difference was observed between prediabetic fasting blood glucose levels (GFBS, VFBs, and PFBS) \((P > 0.05)\) [Table 4]. No significant difference was observed between prediabetic postprandial blood glucose levels (GPPS, VPPS, and PPS) \((P > 0.05)\) [Table 4]. There was highly significant \((P < 0.01)\), positive, and strong correlation \((r > 0.90)\) in diabetics between the glucose levels recorded both in fasting (GFBS, VFBs, and PFBS) and postprandial (GPPS, VPPS, and PPS) [Table 5].

**Nondiabetic group**

Among thirty nondiabetics, no significant difference was observed between fasting blood glucose levels (GFBS, VFBs, and PFBS) \((P > 0.05)\) [Table 3 and Graphs 7 and 8]. No significant difference was observed between postprandial blood glucose levels (GPPS, VPPS, and PPS) \((P > 0.05)\) [Table 3 and Graph 9 and 10]. No significant difference was observed between prediabetic fasting blood glucose levels (GFBS, VFBs, and PFBS) \((P > 0.05)\) [Table 4]. No significant difference was observed between prediabetic postprandial blood glucose levels (GPPS, VPPS, and PPS) \((P > 0.05)\) [Table 4]. There was highly significant \((P < 0.01)\), positive, and strong correlation \((r > 0.80)\) in nondiabetics between the glucose levels recorded both in fasting (GFBS, VFBs, and PFBS) and postprandial (GPPS, VPPS, and PPS) [Table 6].

**Sensitivity and specificity**

In this study, it was found that GFBS gives a sensitivity of 93% and specificity of 100%, respectively, and GPBS gives a sensitivity of 80% and specificity of 96%, respectively.

**Discussion**

Our study is one among the few studies which considered all three parameters that is gingival, peripheral finger stick, and VB glucose levels both in fasting and...
postprandial periods. In this study, a self-monitoring glucometer (Accu-Chek Active, Roche Diagnostics, USA) was used to measure the glucose levels in the blood which oozes out during routine probing. Even in the case of very low gingival bleeding, glucose measurement is possible with a glucometer, due to low volume of blood (3 µl) required to perform the analysis.\cite{9,10} We have taken into account gingival status, rather than periodontal status because diagnosing patients with diabetes mellitus in the gingivitis stage itself gives us a chance of early primary intervention. The correlation between diabetic PFBS and GFBS ($r = 0.977, P = 0.000$) was positive and strong. This study shows a stronger relationship than that reported by Sarlati et al.\cite{11} ($r = 0.91$), and Tsutsui et al.\cite{12} ($r = 0.782$). The correlation between diabetic VFBS and Gingival Crevicular Fasting Blood Sugar (GFBS) ($r = 0.962, P = 0.000$) was positive and stronger. This study shows a stronger relationship than that reported by Patil and Kamalakkannan\cite{13} ($r = 0.736, P = 0.001$). The correlation between Peripheral Finger Prick Postprandial Blood Sugar and GPPS ($r = 0.993, P = 0.000$) was positive and stronger. This study shows a stronger relationship than that reported by Jain

### Table 1: Sociodemographic details of the study participants

| Parameters                  | Diabetics (%) | Nondiabetics (%) | $P$  |
|-----------------------------|---------------|------------------|------|
| Gender                      |               |                  |      |
| Male                        | 18 (60)       | 15 (50)          | 0.604* |
| Female                      | 12 (40)       | 15 (50)          |      |
| Age                         |               |                  |      |
| Male                        | 52.6±3.9      | 52.9±5.2         | 0.777** |
| Female                      | 50.8±3.7      | 51.5±5.0         |      |
| Socioeconomic status        |               |                  |      |
| Upper class                 | 22 (73.3)     | 21 (70)          | 0.952*** |
| Upper middle                | 8 (26.7)      | 9 (30)           |      |
| Lower middle                | 0             | 0                |      |
| Upper lower                 | 0             | 0                |      |
| Lower                       | 0             | 0                |      |

*ANCOVA, **Fischer man, ***Chi-square test. $P>0.05$ not statistically significant
et al.

The correlation between nondiabetic PFBS and GFBS ($r = 0.835$, $P = 0.001$) was positive and stronger. This finding is similar to the study conducted by Patil and Kamalakkannan ($r = 0.93$, $P < 0.001$). The correlation between nondiabetic VFBS and GFBS ($r = 0.893$, $P = 0.000$) was positive and stronger. This finding is similar to the study conducted by Patil and Kamalakkannan ($r = 0.75$, $P < 0.001$). Estimation of sulcular blood glucose levels were previously conducted and showed correlations with capillary blood glucose levels, thereby suggesting that testing sulcular blood may be a valuable tool in identifying potential patients with diabetes. However, the correlation between the two measures can be influenced by a variety of factors such as site of sample collection, sampling methodology, type of instruments used, and duplicate sampling. Regarding site of sample collection, a previous study by Strauss et al. reported that gingival crevicular blood (GCB) samples were suitable to screen for diabetes in persons with sufficient bleeding on probing to obtain a sample without touching the tooth or the gingival margin. In addition, the method of collection of sulcular blood is critical because the resultant glucose values may be altered.

### Table 2: Comparison of various other fasting and postprandial blood glucose level between diabetics and nondiabetics

| Parameters | Diabetics Mean±SD | Nondiabetics Mean±SD | P | Lower CI | Upper CI |
|------------|-------------------|----------------------|---|----------|----------|
| VFBS       | 164.7±37.803      | 95.433±12.226        | 0.000** | 54.813   | 83.853   |
| VPPS       | 240.8±69.643      | 130.0±23.797         | 0.000** | 83.902   | 137.697  |
| GFBS       | 162.5±36.704      | 93.800±11.439        | 0.000** | 54.716   | 82.817   |
| GPPS       | 235.2±71.255      | 129.7±21.713         | 0.000** | 78.276   | 132.723  |
| PFBS       | 162.7±37.525      | 93.533±9.558         | 0.000** | 55.014   | 83.318   |
| PPPS       | 239.0±69.740      | 131.0±21.677         | 0.000** | 81.342   | 134.723  |

Independent t test. **$P<0.001$ very highly significant. VFBS=Venous fasting blood sugar, VPPS=Venous postprandial blood sugar, GFBS=Gingival fasting blood sugar, PFBS=Peripheral fingerstick fasting blood sugar, PPPS=Peripheral fingerstick postprandial blood sugar, GPPS=Gingival postprandial blood sugar, CI=Confidence interval, SD=Standard deviation

### Table 3: Comparison of various fasting and postprandial blood glucose levels within diabetics and nondiabetics

| Group        | Parameters | VFBS Mean±SD | GFBS Mean±SD | PFBS Mean±SD | P     |
|--------------|------------|--------------|--------------|--------------|-------|
| Diabetics    | VFBS       | 164.7±37.803 | 95.433±12.226 | 162.7±37.525 | 0.968 |
|              | VPPS       | 240.8±69.643 | 130.0±23.797  | 239.0±69.740 | 0.952 |
|              | GPPS       | 235.2±71.255 | 129.7±21.713  | 131.0±21.677 | 0.975 |
| Nondiabetics | VFBS       | 162.5±36.704 | 93.800±11.439 | 93.533±9.558 | 0.775 |
|              | VPPS       | 235.2±71.255 | 129.7±21.713  | 131.0±21.677 | 0.975 |
|              | GPPS       | 239.0±69.740 | 131.0±21.677  | 131.0±21.677 | 0.975 |

ANOVA test, $P>0.05$ not statistically significant. VFBS=Venous fasting blood sugar, VPPS=Venous postprandial blood sugar, GFBS=Gingival fasting blood sugar, PFBS=Peripheral fingerstick fasting blood sugar, PPPS=Peripheral fingerstick postprandial blood sugar, GPPS=Gingival postprandial blood sugar

### Table 4: Comparison of various fasting and postprandial prediabetic blood glucose level

| Parameters | VFBS Mean±SD | GFBS Mean±SD | PFBS Mean±SD | P     |
|------------|--------------|--------------|--------------|-------|
| VFBS       | 1.13±6.9     | 1.09±8.4     | 1.07±7.8     | 0.428 |
| VPPS       | 1.56±17.1    | 1.52±17.8    | 1.53±19.2    | 0.863 |
| GPPS       | 1.52±17.8    | 1.53±19.2    | 1.53±19.2    | 0.863 |

VFBS=Venous fasting blood sugar, VPPS=Venous postprandial blood sugar, GFBS=Gingival fasting blood sugar, PFBS=Peripheral fingerstick fasting blood sugar, PPPS=Peripheral fingerstick postprandial blood sugar, GPPS=Gingival postprandial blood sugar
if there is any contamination of the collected sample by the oral tissues or tissue products. Contamination may occur from saliva and oral debris present at the wiped gingival area or from plaque and crevicular fluid on the dental curette. Hence, in the present study, isolating the bleeding gingival site with gauze after scaling and then rapidly sampling blood was transferred directly to the test strip. However, because majority of the patients are usually apprehensive whenever invasive techniques are used, we have incorporated the minimally invasive method where the blood oozing out during routine periodontal examination is checked for diabetes. In this study, it was found that GFBS glucometer cutoff of 125 mg/dl gives a sensitivity of 93% and specificity of 100%, respectively. It was found that in a study conducted by Parihar et al., GFBS gives a sensitivity of 100% and specificity of 98.4%. Multiple measurements of the diabetic patient’s blood glucose allow the practitioner to assess the patient’s diabetic control as the treatment progresses in a better manner. Using the method described in this study, the practitioner can rapidly measure blood glucose many times using the GCB during routine periodontal examination. Apart from this, suspected diabetics can also be screened in the dental office itself and then referred for further investigations if required. Since the measurement of glucose through GCB involves a quick and simple intraoral procedure with minimal cost, dental professionals need to be motivated to implement diabetes screening and feel comfortable and confident in doing so. The limitation of this study was, although most diabetes patients bleed on probing, a small proportion of patients do not bleed on gentle probing. In such cases, capillary blood glucose can be the best method for screening.

Conclusion

The results of the present study indicate that gingival fasting blood and gingival postprandial blood collected during diagnostic periodontal examination may be an excellent source of blood for glucometric analysis. In addition, the technique described is safe, easy to perform, and comfortable for the patients and might therefore help increase the frequency of screening diabetics in dental offices. It can be used as an alternative screening tool for diabetes mellitus. Furthermore, the cost associated with the purchase of a readily available glucometer and individual test strips are extremely modest. Thus, with minimal cost and a limited investment of time for patients and clinicians, dental professionals can play a critical role in supporting their patient’s overall health.

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Conflicts of interest

There are no conflicts of interest.

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