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Gingival crevicular glucose estimation and patient's perception of pain during routine dental examination – a concept based on a novel patented periodontal device

Procena nivoa glukoze u gingivalnom sulkusu i percepcija bola kod pacijenata tokom rutinskog stomatološkog pregleda – koncept zasnovan na novopatentiranom parodontalnom uređaju

Nabeeh Abdullah AlQahtani, Mohasin Abdul Khader, Mukhatar Ahmed Javali

King Khalid University, College of Dentistry, Department of Periodontics and Community Dental Sciences, Abha, Kingdom of Saudi Arabia

Abstract

Background/Aim. Diabetes mellitus (DM) is a common metabolic disease that causes high mortality and morbidity worldwide. Therefore, in order to implement prevention strategies, physicians need to identify this condition as early as possible. The aim of the study was to test the concept of a novel periodontal device that can be attached to a glucose monitoring device as an innovative tool to screen for periodontitis and DM simultaneously during a routine dental examination. Hence, the correlation of blood glucose between the conventional finger-prick blood glucose (FPBG) and gingival crevicular blood glucose (GCBG) method, along with an estimation of the patient's pain perception by visual analog scale (VAS) was examined. **Methods.** A cross-sectional comparative study was conducted among 250 participants whose GCBG and FPBG were estimated. The VAS score scale was recorded for each patient immediately after the procedure. **Results.** The mean GCBG value was 151.19 ± 42.64 mg/dL, while the mean FPBG was 150.48 ± 42.95 mg/dL, showing a high Pearson's correlation ($r = 0.9932$; $p < 0.00001$). The Mann-Whitney *U* test for VAS score between both groups showed a statistically significant difference ($p < 0.00001$). **Conclusion.** The GCBG method was well tolerated by patients, and highly correlated with peripheral blood glucose levels. The proposed concept of the novel periodontal device appeared to be a feasible option for examining periodontium and screening DM simultaneously in dental clinics.

Key words:
blood glucose; dental instruments; diabetes mellitus; fingers; gingival crevicular fluids; pain measurement; periodontitis.

Apstrakt

Uvod/Cilj. Dijabetes melitus (DM) je česta metabolička bolest, koja izaziva visok morbiditet i mortalitet širom sveta. Zbog toga, kako bi primenili strategije prevencije, lekari moraju što ranije da identifikuju to stanje. Cilj rada bio je da se testira novi parodontalni uređaj koji se može povezati sa uređajem za praćenje nivoa glukoze u krvi kako bi tokom rutinskog stomatološkog pregleda istovremeno vršio skrining parodontitisa i DM. Stoga, ispitana je korelacija nivoa glukoze u krvi izmerenih primenom konvencionalne metode merenja glukoze u krvi iz prsta (KMIP) i metode merenja glukoza u krvi iz gingivalnog sulkusa (UKGS), uz istovremenu procenu percepcije bola pacijenata vizuelnom analognom skalom (VAS). **Metode**. Komparativna studija preseka sprovedena je među 250 ispitanika kojma su procenjeni UKGS i KMIP. Bodovna skala VAS zabeležena je za svakog pacijenta odmah nakon postupka. **Rezultati.** Prosečna vrednost glukoze UKGS iznosila je 151,19 ± 42,64 mg/dL, dok je KMIP vrednost glukoze bila 150,48 ± 42,95 mg/dL, što je pokazalo visoku *Pearson*-ovu korelaciju ($r = 0,9932$; $p < 0,00001$). Mann-Whitney *U* test za VAS skor između obe grupe pokazao je statistički značajnu razliku ($p < 0,00001$). **Zaključak**. Metodu UKGS pacijenti dobro tolerišu, a njene vrednosti značajno korelišu sa nivoom glukoze u perifernoj krvi. Predloženi koncept korišćenja novog parodontalnog uređaja pokazao se kao pogodan izbor za ispitivanje parodoncijuma i istovremeni skrining DM u stomatološkim klinikama.

Ključne reči:
glukoza u krvi; stomatološki instrumenti; dijabetes melitus; prsti; gingivalna sulkusna tečnost; bol, merenje; periodontitis.

Correspondence to: Nabeeh A AlQahtani, King Khalid University, College of Dentistry, Department of Periodontics and Community Sciences, Abha, Kingdom of Saudi Arabia. E-mail: nabeehab@kku.edu.sa

Introduction

Diabetes mellitus (DM) is a common metabolic disease that causes high mortality and morbidity worldwide. There has been a steady increase in its prevalence, as a recent report shows that it has increased from 4.7% to 9.3% over the last few decades. Researchers expect the numbers to rise from 463 million to 578 million cases in the next decade [1]. The rising medical expenses associated with DM begin much before its diagnosis. Therefore, physicians need to identify this condition early to implement prevention strategies [1]. DM causes periodontal breakdown [2] and peri-implantitis [3]. Observational [4] and longitudinal studies [5, 6] demonstrate that DM increases the risk of periodontitis in adults [7, 8]. The role of uncontrolled DM as a risk factor for periodontal disease and tooth loss has been widely studied [9, 10]. Moreover, persons with DM also have delayed wound healing [11]. Hence, screening for elevated blood glucose (BG) levels prior to any dental procedure is crucial for achieving adequate glycemic control before any surgical procedure or dental implant placement [10].

In our body, glucose is found in blood and other secretions such as intracellular fluids, tears, saliva, and urine. Its concentration is highest in the arterial circulation [7]. However, in the laboratory, venous blood samples are usually taken to diagnose DM using the glucose oxidase method. Nevertheless, if the tourniquet is left for a long time, BG concentrations can fluctuate as much as 25 mg/dL [12]. The capillary BG levels used in the finger-prick blood glucose (FPBG) estimation are found to be between venous and arterial concentrations. The chairside glucometer used to monitor BG levels typically uses glucose oxidase biosensors to determine BG concentration from the FPBG method using a lancet. This technique is a direct and accurate method for assessing BG concentrations. Yet, it has been found that patients are often distressed while doing this test due to pain [13, 14].

Recent studies show that gingival crevicular blood glucose (GCBG) is emerging as an alternative source of blood for determining BG concentration [15–19]. Bleeding on probing (BOP) occurring in the gingival crevice during routine dental examination is an objective sign of periodontal breakdown. Apparently, this bleeding during routine periodontal probing can be used to estimate the BG level instead of the traditional FPBG [20–23]. Many invasive dental procedures require persons with DM to first screen for their current blood sugar status since hyperglycemia and hypoglycemia can be detrimental [4, 16]. For most persons with DM, especially the elderly who report to dental procedures, BG levels should be regularly monitored [4, 16]. That is not feasible with traditional BG detection methods; thus, continuous glucose monitoring in these persons using the GCBG method during lengthy dental procedures may be of great clinical application value and more in line with market trends. Although there are many glucometers in the global market, none of these have the mechanism to measure periodontitis and screen for DM simultaneously. Therefore, this study aimed to test the concept of a novel patented periodontal device that can be attached to a glucose monitoring device as an innovative tool to screen for periodontitis and DM simultaneously during a routine dental examination. Accordingly, the correlation of BG between the conventional FPBG method and the GCBG method was assessed.

Methods

Clinical protocol

We conducted a cross-sectional comparative study among 180 participants who reported to the Outpatient Department, College of Dentistry, King Khalid University, Saudi Arabia, using a randomized sampling technique from April to November 2021. Ethical Approval was obtained from the Institutional Review Board of King Khalid University, Saudi Arabia (IRB/KKUCOD/ETH/2020-21/053). The study followed the code of ethics in the Declaration of Helsinki (version 17c, 2004). Complete information about the study was given to the participants in their language, and informed consent was obtained before the commencement of the study.

Participants

Patients older than 18 years who had chronic periodontitis (with at least one bleeding site) were recruited for the study. Patients with the following conditions were excluded: (1) recent use of antibiotics; (2) patients with hematological disorders; (3) use of medications that interfere with coagulation; (4) presence of any systemic disorder.

Sources of data and details of methods of assessment

Patients who met the inclusion criteria were taken for the study after obtaining informed consent. They reported to the clinic at 8 am to have their glucose levels recorded. At first, the patients underwent periodontal probing using the University of Michigan “O” periodontal probe with Williams graduations at six sites on each tooth. A single examiner carried out these examinations to detect each patient’s bleeding gingival site. A GCBG sample was collected from the site with maximum inflammation and bleeding [16]. Removal of a piece of supragingival calculus was needed in some cases to collect blood from the gingival sulcus. About 10 to 15 μL of blood sample was collected after isolating the area with cotton rolls to prevent saliva contamination and drying with compressed air. Glass capillary tubes were used to transfer the blood to the test strip that was already loaded into the glucometer following the manufacturer’s instructions.

Patented device

A device for simultaneous measuring of periodontitis (in terms of clinical attachment level, probing depth, and bleeding on probing) and DM (in terms of peripheral BG levels) has been recently granted a patent (Patent Number: SA 6757 B – Saudi Arabia; patented February 2020). The patented glass periodontal probe with markings that can be

attached to a glucose monitoring device is an innovative tool to screen for peripheral BG levels and periodontitis simultaneously during a routine dental examination. It is a manual periodontal probe with 1 mm graduations, a small, battery-powered glucometer, and a display screen attached to its handle. The probe tip is a small glass capillary tube of 0.5 mm that collects blood oozing from the gingival sulcus/pocket following routine periodontal pocket probing and transfers it to the test strip of a glucose self-monitoring device attached to the handle of the probe. Graphical presentations of the device are presented in Figure 1 (a–d).

Visual Analog Scale

After blood sugar analysis using both methods, the patients were asked about their perception of pain during each method, which was marked as Visual Analog Scale (VAS) pain [24] using a 10 mm VAS scale within 10 min of the procedure. This scale has a straight line, and the left end of the scale was marked as "no pain" and the right end as "worst imaginable pain".

Statistical analysis

A subject-level analysis was performed statistically for variables using SPSS software for Windows, Version 22.0. (SPSS Inc., Chicago, IL, USA). The mean value and standard deviation (SD) were calculated for each variable measured. Karl Pearson's product-moment correlation was done to determine associations between the two techniques of determining BG levels. A Scatter plot of the linear relationship between the two techniques of BG determination was drawn. Differences in mean values between the pain scores were assessed using the Mann-Whitney *U* test. All statistical procedures were performed at a significance level of 5% ($p < 0.05$).

Results

All 180 participants (88 males and 92 females) completed this study. The mean age of the participants was 41.65 ± 9.68 years. The mean GCBG value was 151.19 ± 42.64 mg/dL, while the FPBG value was 150.48 ± 42.95 mg/dL

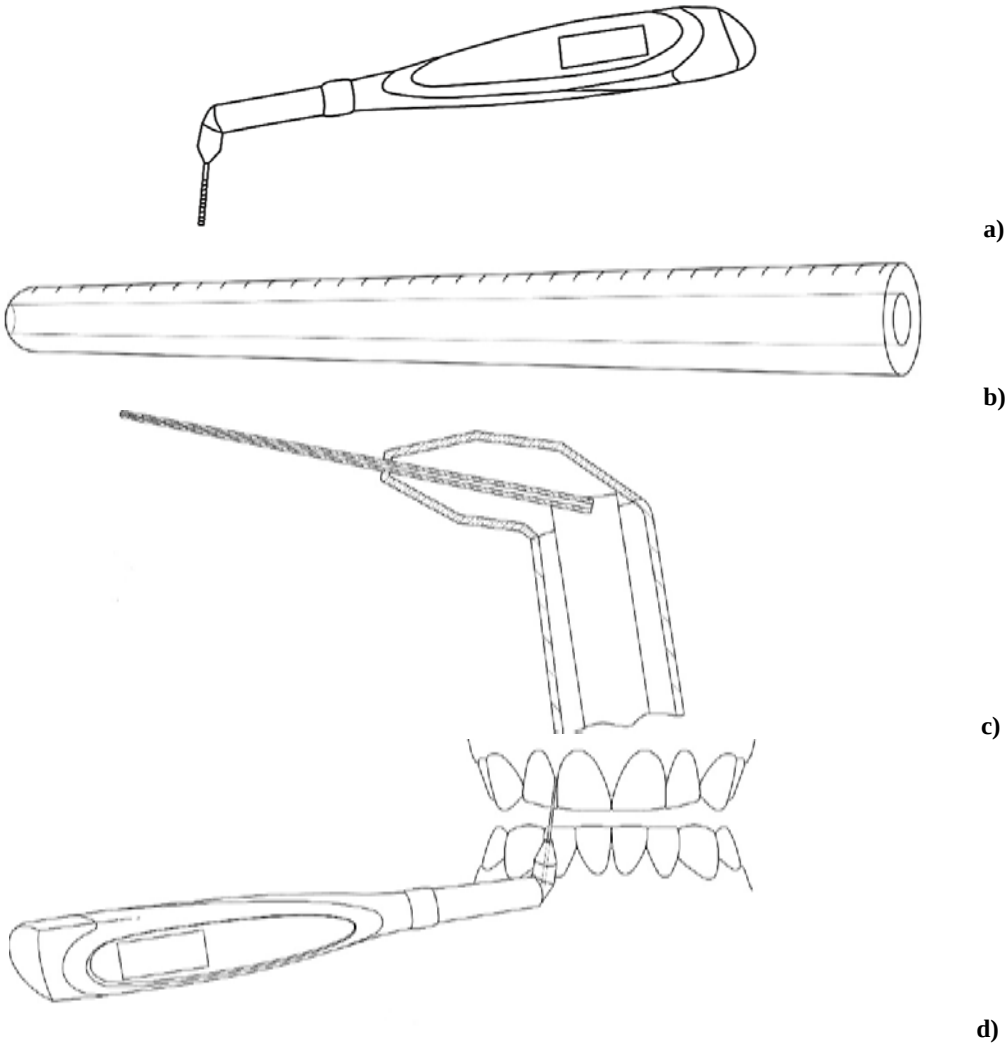

Fig. 1 – a) Graphical representation of the unique patented periodontal device; b) The proposed glass probe of the patented periodontal device; c) Attachment of the proposed glass probe to the self-monitoring glucometer; d) Proposed mode of application of the patented device.

Table 1

The mean and standard deviation of blood glucose using GCBG and FPBG methods

GCBG (mg/dL)	FPBG (mg/dL)	*p*-value	*t*-value
151.19 ± 42.64	150.48 ± 42.95	0.437	0.158

GCBG – gingival crevicular blood glucose; FPBG – finger-prick blood glucose. The results are expressed as mean ± standard deviation.

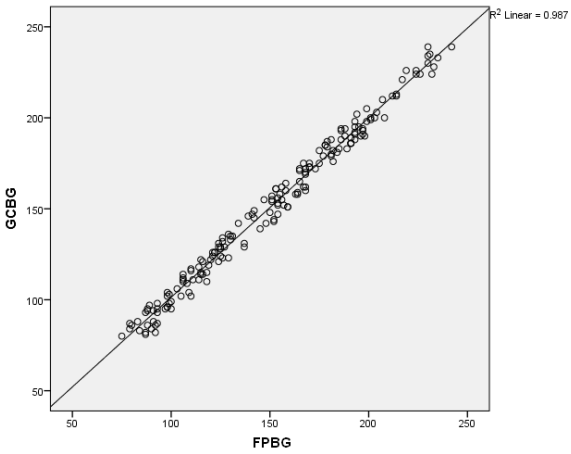

Fig. 2 − Scatter plot of the linear relationship between gingival crevicular blood glucose (GCBG) and finger-prick blood glucose (FPBG).

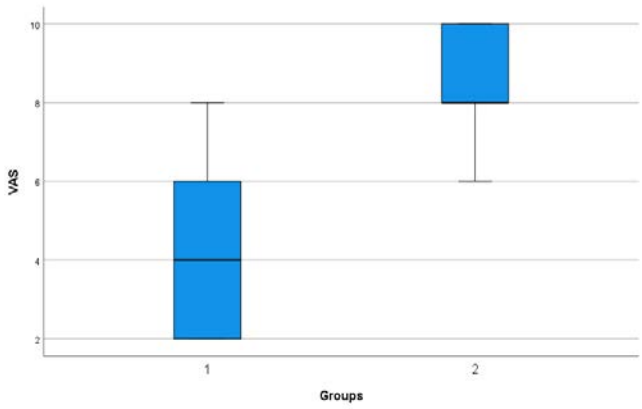

Fig. 3 − Box plot for the mean of visual analog scale (VAS) gingival crevicular (GC) group (VAS-GC) and VAS finger-prick (FP) group (VAS-FP). Group 1 – VAS-GC; Group 2 – VAS-FP.

(Table 1). This difference was not statistically significant ($p = 0.437$).

In order to understand the correlation between these two techniques, Karl Pearson's product-moment correlation was done, which showed a very high coefficient (r = 0.9932) between the two methods ($p < 0.00001$).

Comparison between the difference in the mean VAS score was tested using the Mann-Whitney *U* test for VAS in the gingival crevicular (GC) group (VAS-GC) (4.71) and VAS in the finger-prick (FP) group (VAS-FP) (8.63); it showed a statistically significant difference ($p < 0.00001$).

Figure 2 shows the linear relationship between GCBG and FPBG. The regression equation for *Y* was 1.00043*X* - 0.77668. The box plot representation for the mean of VAS-GC and VAS-FP is shown in Figure 3.

Discussion

The concept described in this study was tested by a study that checked the correlation of BG between the conventional FPBG and GCBG methods. The mean GCBG value was 151.19 ± 42.64 mg/dL, while the mean FPBG value was 150.48 ± 42.95 mg/dL. A dental surgeon can actively screen patients for BG levels during a routine periodontal examination. Early detection of DM can also reduce the financial burden and deterioration of oral and periodontal health. That is even more relevant in the case of undiagnosed DM, which can be referred to the physician for appropriate management of the condition. Poorly controlled DM risks developing periodontal breakdown and adversely affects treatment outcomes. Therefore, this study tested the concept of a novel patented periodontal device that can be attached to a glucose monitoring device to screen for periodontitis and DM simultaneously during routine dental examinations. Several studies report a strong positive correlation between gingival BG levels and peripheral BG levels [12–14, 16, 17, 19, 23]. Many authors have used this technique to detect BG levels and screen for persons with DM in the dental office during periodontal treatment [16, 17, 19, 25–28]. The present study showed an almost perfect correlation (r = 0.9932) between GCBG and FPBG methods ($p < 0.00001$) which was in accordance with the findings of previous studies that show a good correlation between crevicular and peripheral BG levels [14, 17–19, 26, 29]. Contrary to these results, a report by Muller and Behbhani [25] in a Kuwaiti population did not demonstrate a correlation between gingival crevice blood (GCB) and capillary finger-stick BG levels. GCB samples from sites that showed sufficient BOP were useful for screening BG levels [29]; participants with sufficient BOP had a higher correlation coefficient (r = 0.89) and acceptable limits of agreement (-27.1 to 29.7).

Variations in the number of blood samples used in different studies raised questions about the feasibility of the GCBG method during routine dental examinations [30]. Parker et al. [30] used 10–15 µL gingival blood samples, a large volume present only in sites with periodontal inflammation and not always seen. On the other hand, Beikler et al. [20] used only 3 µL of blood in a self-monitoring device in periodontitis patients. Muller and Behbhani [25] reported using only 0.3 µL of a blood sample, although sufficient bleeding was not seen in

some cases. This study also reports low agreement and broader limits of repeatability when GCBG was considered.

The present study is one of those that propose a noninvasive/minimally invasive method to monitor BG levels and, at the same time, record periodontal pocket depth. Therefore, this device can simultaneously screen DM while detecting periodontal disease. Moreover, the safety features of this design include the rounded tip of the probe so that it does not cause any injury to the gingival tissue during insertion. It is also important that the probe attached to the model is disposable in order to maintain infection control protocol.

Although some studies mention a GCBG as a painless technique [20, 30], none of these have measured pain using any pain scale. We chose to report on patients' perceptions as understanding that is known to enhance the effectiveness of care provided [31]. Periodontitis patients and practitioners [32] report dental visits suitable for screening BG, and patients preferred the GCBG method to the FPBG method.

Several reports indicate that gingival crevicular blood is a feasible and quick method for screening BG levels as it can be performed as a chairside screening test. However, the application of this technique is limited to a routine test because gingival crevicular blood depends on the presence of inflammation and can be available only when there is periodontal inflammation. In fact, the ability of this technique to screen with high sensitivity needs to be further tested in the presence of lower periodontal inflammation. As a result, when periodontal inflammation subsides following periodontal therapy treatment, minimal or no bleeding (less than 4 μL of blood) can limit the utility of this technique. The possible contamination or dilution of crevicular blood following periodontal probing by gingival crevice fluid needs to be explored further. Furthermore, the probability of increased glucose levels in gingival crevice fluid from sites of periodontal inflammation compared to healthy sites also needs to be considered [33]. Our team plans future studies to evaluate the sensitivity, specificity, and predictive values of the GCBG method to explore its applicability in screening persons with DM in a larger population sample before and after periodontal therapy.

Conclusion

Within the limitations of the study, a significant difference was seen in the pain score between the VAS-GC group and the VAS-FP group. The use of the presented proposed concept of the unique patented periodontal device appears to be a feasible option for simultaneously examining the state of periodontium and screening for DM in dental clinics. Additional longitudinal studies should be done in a larger population sample to understand the clinical applicability and diagnostic accuracy of the presented device.

Conflicts of interest

The authors declare no conflict of interest.

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