Original Article

Comparison of the subgingival temperature of smokers and nonsmokers in healthy and diseased sites of gingiva in association with sublingual body temperature

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Abstract

Background: To compare the subgingival temperature in healthy and diseased sites of gingiva in smokers and non-smokers using a modified digital thermometer. To also find whether subgingival temperature measurements can be used as reliable indicator of periodontal disease activity. **Materials and Methods:** Participants for this study comprised 50 males, 25 smokers and 25 non-smokers with mild to moderate periodontitis, aged 25-40 years and had four maxillary incisor teeth (12, 11, 21, 22) intact. For each participant, six sites around each tooth were examined. Hence, a total of 24 sites for each participant were examined. The clinical parameters used were probing pocket depth and gingival bleeding index. **Results:** Sublingual and subgingival temperature was found to be warmer in smokers compared to non-smokers. Subgingival temperature was more in diseased sites than healthy sites in both smokers and non-smokers. The mean temperature differential of diseased sites in smokers was more compared to non-smokers. Mean probing pocket depth was higher in smokers, but bleeding sites were less. **Conclusion:** Subgingival temperature measurement was found to be a good indicator of periodontal disease activity.

Keywords: Gingivitis, periodontal pocket, temperature, tobacco smoking

Introduction

One of the most difficult problems in diagnosing and treating periodontal disease is predicting the site where disease activity will increase. The routine clinical parameters used for assessing periodontal disease activity are less reliable in predicting disease activity at individual sites.[1,2] At present, periodontal pocket depth measurement is the principal clinical method in periodontal diagnosis and is inherently inadequate because it fails to distinguish between active and inactive disease.[3]

Temperature elevation has been acknowledged as an indicator of inflammation since the 2nd century AD—when Celsius included "calor" (temperature) as one of the four cardinal signs of inflammation.[4] However, body temperature varies to a certain extent with exercise and surrounding temperature. In some situations, the rise or fall in temperature occurs locally in an affected area of the body which results in localized inflammation, degeneration, circulatory disturbances, and increased metabolic activity of an organ or a part of the body.[5]

One of the major risk factors for destructive periodontal diseases is smoking. Smokers, in particular, have more loss of attachment and severe bone loss compared to nonsmokers. However, gingival redness and bleeding on probing are suppressed in smokers.[6] Reliance on current methods of determining disease activity may lead to errors in diagnosis and treatment, primarily, because bleeding on probing and probing depth measurements are not accurate enough to evaluate disease activity, especially in smokers

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Received: 01-07-2019 **Revised:** 22-08-2019 **Accepted:** 10-09-2019

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_516_19

How to cite this article: Singh DK, Kumar G. Comparison of the subgingival temperature of smokers and nonsmokers in healthy and diseased sites of gingiva in association with sublingual body temperature. J Family Med Prim Care 2019;8:3166-72.

due to suppressed bleeding on probing.[7] Attempts have been made to develop other measures to evaluate disease activity with unreliable clinical signs. One such measure is the subgingival temperature that can differentiate between diseased and healthy periodontal sites in the majority of cases. Temperature changes accompany inflammatory process, and therefore diagnostic and prognostic information can be obtained by recording the temperature of the affected area.[8] A temperature-sensitive probe, Periotemp, has been developed to detect periodontal pocket temperature. It is a commercially available device used to measure subgingival temperature, which is not available in India. Studies suggest that subgingival temperature measurement with Periotemp provides a simple and sensitive means of detecting disease activity.[9,10]

To date, only a few studies have been conducted to evaluate the possible use of temperature measurement as a diagnostic aid in periodontal disease. Hence, this study compares sub-gingival temperature in healthy and diseased sites of smokers and non smokers using modified digital thermometer.

Aims and Objectives

The aim of this study was to compare subgingival temperatures between healthy and diseased sites in both smokers and nonsmokers using a modified digital thermometer and find whether subgingival temperature measurement can be used as a reliable indicator of periodontal disease activity.

Figure 1: Armamentarium

Figure 3: Probing of diseased site

Materials and Methods

The subjects for this study were selected from the outpatient department [Figures 1-5].

Inclusion criteria

The subjects comprised of 50 males, aged 25–40 years, who had four maxillary incisor teeth, that is, 12, 11, 21, and 22, intact. Subjects having mild-to-moderate periodontitis, diagnosed on the basis of gingival and periodontal indices, were selected and divided into two groups. For each subject, six sites around each tooth were examined; so, a total of 24 sites for each subject were examined. For 50 subjects, a total of 1200 sites were examined.

Group I (Smokers): Twenty-five subjects who had been smoking more than five cigarettes a day for more than 5 years were included in this group. The number of cigarettes consumed daily was recorded along with the number of years the subjects had been smoking.

Group II (Nonsmokers): Twenty-five subjects who had never smoked were included in this group.

Figure 2: Probing of non-diseased site

Figure 4: Sub-gingival temperature measurement at non-diseased site

Exclusion criteria

a. Individuals smoking >5 cigarettes per day
b. Individuals smoking for >5 years
c. Female patients
d. Individuals with systemic conditions and on medications
e. Individuals with missing four maxillary anterior teeth no., 12.11.21 and 22.

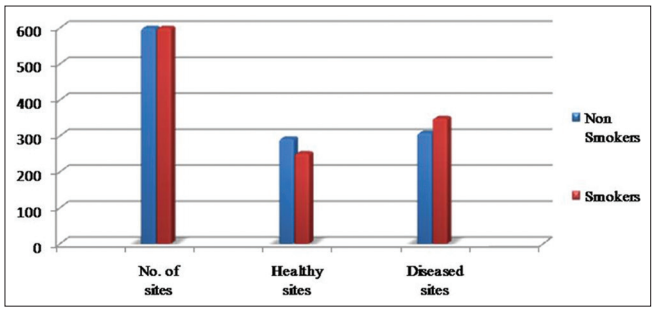
Modified digital thermometer

The instrument used for recording subgingival temperature was a modification of the commercially available digital thermometer (Power: 1.55V.D.C; Accuracy: 0.1°C;

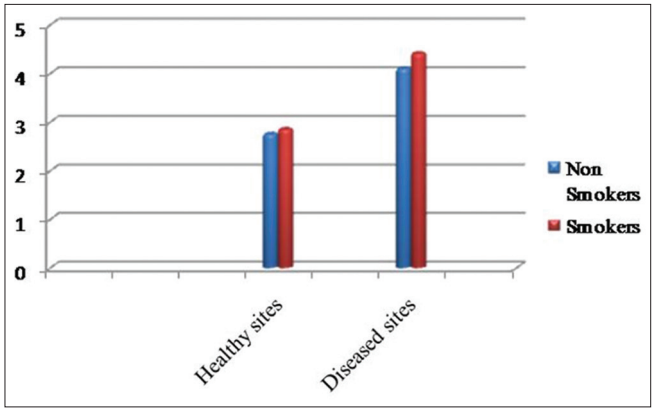
Dimensions: 160 × 17.9 × 9.5 mm; Sensor diameter: 0.88 mm; Sensor length: 3.4 mm; Weight: 10.47 g; Stainless steel needle: 22 gauge, 3 cm length). A thermistor connected to a battery-powered digital thermometer was used to measure the temperature. The bulbous sensor was modified to a thickness of 0.88 mm and a length of 3.4 mm. The design of the original thermometer remained the same except for the modification of the sensor and the flexible thermometer neck for easy insertion into the gingival sulcus. The temperature measurement was recorded in centigrade.

The sensor was passed through a commercially available 22-gauge, 3-cm long stainless steel needle, which was angulated for easy access and inserted into the gingival sulcus. The thermometer was designed to beep when the temperature recording was stabilized in the digital display window which was ready for recording.

Figure 5: Sub-gingival temperature measurement at diseased site



Graph 1: Total study subjects and sites



Graph 2: Mean probing pocket depth

Methodology

All the clinical examinations were carried out by the same examiner. The clinical parameters used were probing pocket depth and gingival bleeding index.

Temperature measurements

Each subject rested in the dental chair for at least 30 mins, and the temperature recordings were made without a chair light, while they were instructed to breathe through the nose to eliminate the effect of expired air on temperature recording. No measurements were made within 30 mins of the subject's last food, drink intake or the last cigarette smoked. In addition, none of the subjects had brushed, flossed, or rinsed their teeth in the preceding 30 mins to eliminate temperature variation from another source. Furthermore, temperature measurements were not repeated as the physical stimulation of the first reading may affect subsequent temperature readings.

Table 1: Total study subjects and sites

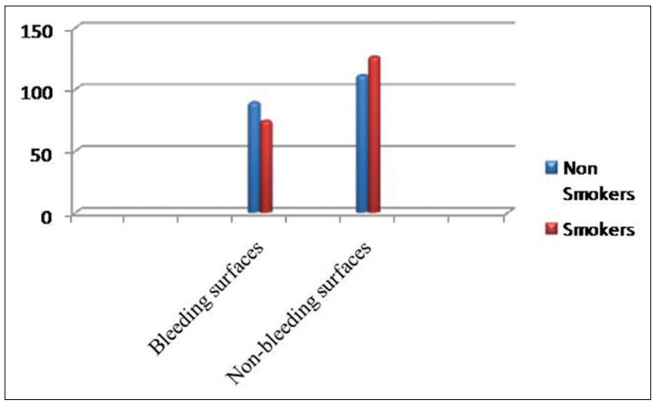
	Subjects		Healthy sites	Diseased sites
Total	50	1200	543	657
Nonsmokers	25	600	292	308
Smokers	25	600	251	349

Table 2: Mean probing pocket depth

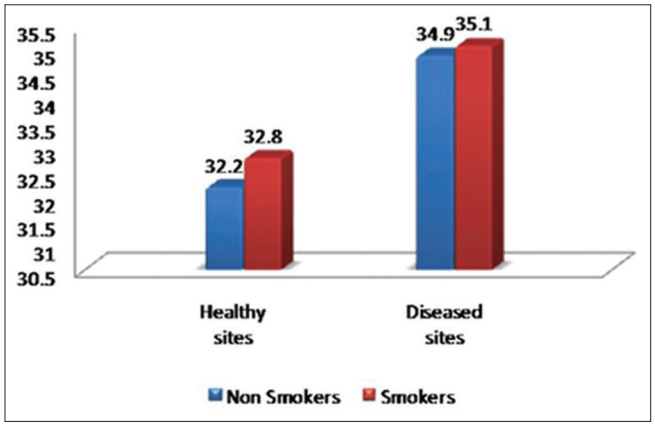
	Healthy Sites			Diseased Sites		
	No. of sites	Mean (Mm)	± S.D.	No. of sites	Mean (Mm)	± S.D.
Total	543	2.8	0.49	657	4.26	0.46
Nonsmokers	292	2.75	0.28	308	4.10	0.39
Smokers	251	2.85	0.71	349	4.42	0.53
Healthy site: Smokers vs. Nonsmokers				Healthy sites: Smokers vs. Nonsmokers		
Diseased sites: Smokers vs. Nonsmokers				Diseased sites: Smokers vs. Nonsmokers		
Nonsmokers: Healthy vs. Diseased Sites				Nonsmokers: Healthy vs. Diseased Sites		
Smokers: Healthy vs. Diseased Sites				Smokers: Healthy vs. Diseased Sites		

Table 3: Bleeding and nonbleeding surfaces

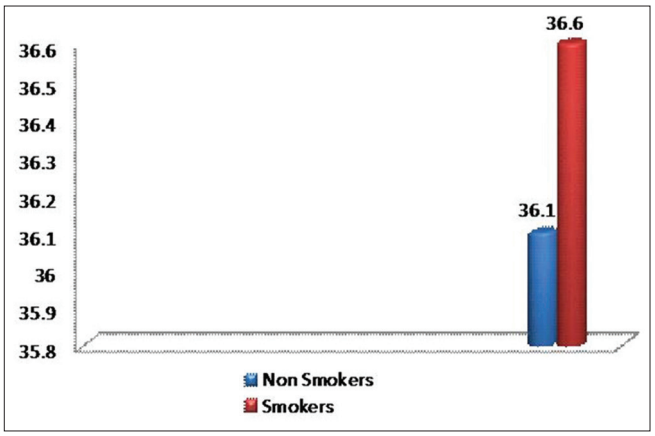
	Subjects	No. of surfaces	Bleeding surfaces	Percentage	Nonbleeding surfaces	Percentage
Total	50	400	163	41%	237	59%
Smokers	25	200	74	37%	126	63%
Nonsmokers	25	200	89	44.5%	111	55.5%



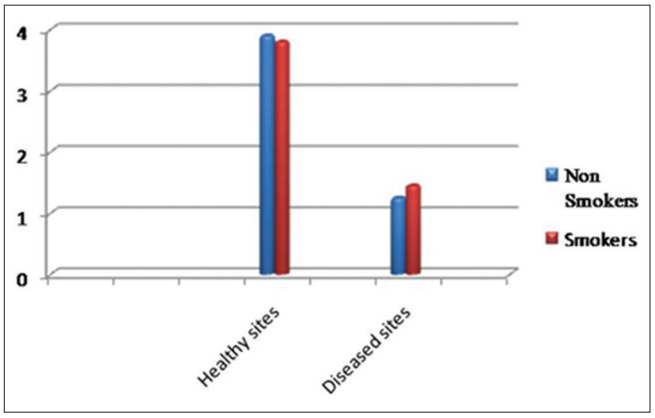
Graph 3: Bleeding and non-bleeding surfaces



Graph 5: Mean sub-gingival site temperature



Graph 4: Mean sublingual temperatures



Graph 6: Mean temperature differentials

In each subject, six sites—disto buccal, mid buccal, mesio buccal, disto palatal, mid palatal, and mesio palatal—around each of the four maxillary incisor teeth (12, 11, 21, and 22) were chosen. For each subject, 24 sites were examined to record the subgingival temperature. Sites were classified as healthy or diseased using probing pocket depth and gingival bleeding index.

Sublingual temperature measurement

The sublingual temperature was recorded 3–5 mins after subgingival temperature measurements for each subject with the same thermometer, while subjects were asked to seal their lips and not move the tongue until the temperature recording had been completed. The sublingual temperature was recorded by placing the tip of the thermometer in the lingual sulcus adjacent to the last molar tooth.

Temperature differential: (delta − *t*)[7,8,10]

Temperature differential was derived by subtracting the sublingual temperature from the average subgingival temperature for each subject. This yields a series of values independent of individuals and eliminates subject-to-subject systemic temperature variations.

Statistical analysis

Mean and standard deviation were calculated for the quantitative data. The differences between probing depths, mean sublingual temperatures, mean subgingival site temperatures, and mean temperature differentials (Delta T) for healthy and diseased sites were compared between smokers and nonsmokers using Student's *t*-test.

Results

A total of 50 male subjects were included in the study—25 smokers and 25 nonsmokers. Out of 1200 sites (600 sites in each group), 543 were classified as healthy and 657 were diseased. Among smokers, 251 were healthy and 349 were diseased sites. Among nonsmokers, 292 were healthy and 308 were diseased sites [Table 1 and Graph 1].

Table 4: Mean sublingual temperatures

	No. of subjects	Mean temperature sub lingual (TSL) (°C)	± S.D.
Total Subjects	50	36.35	0.44
Nonsmokers	25	36.1	0.51
Smokers	25	36.6	0.36

t value: 4. *P*: <0.001: Smokers vs. Nonsmokers

Table 5: Mean subgingival site temperature (°C)

	Healthy Sites			Diseased Sites		
	No. of sites	Mean Temperature Sub Gingival (TS) (°C)	± S.D.	No. of sites	Mean TS (°C)	± S.D.
Nonsmokers	292	32.2	1.05	308	34.9	1.33
Smokers	251	32.8	1.09	349	35.1	1,42
Total Sites	543	32.5	1.07	657	35.0	1.38
Healthy sites: Smokers vs. Nonsmokers			*t* value: 3.26 *P*: <0.01			
Diseased sites: Smokers vs. Nonsmokers			*t* value: 1.8 *P*: not significant			
Nonsmokers: Healthy vs. Diseased Sites			*t* value: 27.5 *P*: <0.001			
Smokers: Healthy vs. Diseased Sites			*t* value: 21.5 *P*: <0.001			

Table 6: Mean temperature differentials all sites

	No. of Sites	Mean ΔT(°C)	± S.D.
Total	1200	2.65	1.04
Nonsmokers	600	2.55	0.85
Smokers	600	2.75	1.12

t value: 3.48. *P*<0.01: Smokers vs. Nonsmokers

Table 7: Mean temperature differentials

	Healthy Sites			Diseased Sites		
	No. of Sites	Mean AT	+ S.D.	No. of Sites	Mean AT	+ S.D.
Total Sites	543	3.85	0.95	657	1.35	1.05
Nonsmokers	292	3.9	0.82	308	1.25	1.16
Smokers	251	3.8	1.08	349	1.45	0.92

Healthy sites: Smokers vs. Nonsmokers: *t* value: 1.22, *P*: not significant. Diseased sites: Smokers vs. Nonsmokers: *t* value: 2.43, *P*: <0.05. Nonsmokers: Healthy vs. Diseased Sites: *t* value: 27.4, *P*: <0.001. Smokers: Healthy vs. Diseased Sites: *t* value: 34.3, *P*: <0.001

The mean probing pocket depth for healthy sites was 2.75 mm for nonsmokers and 2.85 mm for smokers. For diseased sites, the mean probing pocket depth was 4.10 mm for nonsmokers and 4.42 mm for smokers.

When pocket depth for healthy sites between smokers and nonsmokers was compared, moderately significant ($P < 0.05$) difference was found, with smokers showing a higher probing pocket depth of 0.l mm.

A statistically high significance ($P < 0.001$) was found when pocket depths for diseased sites between smokers and nonsmokers were compared, with smokers showing a higher probing pocket depth of 0.3 mm.

When probing pocket depths of healthy and diseased sites within the smokers group were compared, a highly significant ($P < 0.001$) difference was found with diseased sites showing higher probing pocket depth. Similarly, diseased sites within nonsmokers showed higher probing pocket depth compared to healthy sites [Table 2 and Graph 2].

From a total of 200 surfaces examined, smokers had 74 bleeding and 126 nonbleeding surfaces; nonsmokers had 89 bleeding and 111 nonbleeding surfaces. For smokers, 37% of the surfaces bled on probing and 63% did not. For nonsmokers, 44.5% surfaces bled on probing and 55.5% did not. The percentages of bleeding surfaces for smokers were less compared to nonsmokers [Table 3 and Graph 3].

Mean sublingual temperature measurements were compared for each group and a difference was found between smokers and nonsmokers [Table 4 and Graph 4]. The mean sublingual temperature was 36.6°C for smokers and 36.1°C for nonsmokers. Smokers showed a mean sublingual temperature of 0.5°C higher than nonsmokers, which was statistically highly significant ($P < 0.001$).

The mean subgingival temperatures for healthy and diseased sites in each group are shown in Table 5 and Graph 5. There was a significant difference where the mean site temperatures were approximately 0.4°C warmer in smokers compared to nonsmokers.

For healthy sites, a moderately significant difference ($P < 0.01$) was found with smokers showing warmer mean site temperatures. For diseased sites, no significant difference was found.

When mean subgingival site temperature of healthy and diseased sites of smokers was compared, it was found to be highly significant ($P < 0.001$), with diseased sites showing warmer temperatures.

When mean subgingival site temperature of healthy and diseased sites of nonsmokers was compared, it was found to be highly significant ($P < 0.001$), with diseased sites showing warmer temperatures.

Differences in the mean temperature differential value were found to be moderately significant ($P < 0.01$) between smokers and nonsmokers when all the sites were compared, with smokers showing a higher mean temperature differential [Table 6 and Graph 6].

For healthy sites, the mean temperature differential for all subjects was 3.85°C lower than the sublingual temperature; the value was 3.8°C lower for smokers and 3.9°C lower for nonsmokers.

For diseased sites, the mean temperature differential for all subjects was 1.35°C lower than the sublingual temperature; it was 1.45°C lower for smokers and 1.25°C lower for nonsmokers.

For healthy sites, smokers showed a mean temperature differential of 0.1°C lower than nonsmokers. For diseased sites, nonsmokers had a mean temperature differential of 0.2°C lower than smokers [Table 7].

Discussion

At any microbial invasion site, there is an increase in cellular and molecular activity. The release of inflammatory chemical mediators resulting from infection produces vasodilatation, and venous blood returning from such a site is warmer than the arterial blood supplying the site. This means that the increase in cellular activity generates heat which warms the blood passing through the site. Such an increase in the temperature within a periodontal pocket would thus be an indication of disease activity.[11-14]

Nonetheless, clinical trials investigating periodontal disease have not incorporated subgingival temperature. This is largely due to two factors. The first is the apparent lack of a clinical instrument to reliably measure subgingival temperature. The second is the perceived absence of adequate clinical precedent for measuring subgingival temperature.[12] Though clinical signs such as redness and swelling have been traditionally used to diagnose gingivitis, in combination with attachment loss for marginal periodontitis, they have limited sensitivity and specificity for assessing diseases.[7,15-18]

The inclusion and exclusion criteria followed by Sabyasachi Mukherjee *et al.*[19,20] and Horvath S.M *et al.*[20] were adopted in our study. Subjects with mental or emotional stress were excluded since they have temperature differences as described in the previous studies by Maeda *et al.*[21]

In this study, the sublingual and the subgingival temperatures were recorded using a modified digital thermometer. Out of 1200 sites, 543 were healthy and 657 were diseased. Nonsmokers had 292 healthy and 308 diseased sites. Smokers had 251 healthy and 349 diseased sites. For smokers, there were 74 bleeding sites and 126 nonbleeding sites. For nonsmokers, there were 89 bleeding sites and 111 nonbleeding sites. Smokers had less number of bleeding sites compared to nonsmokers. This was in accordance with the studies conducted by Preber and Bergstrom *et al.*,[22] Markannen *et al.*,[23] and Kent J *et al.*[24]

In this study, there was a moderately significant increase of subgingival temperature with the increase in probing pocket depth for both smokers and nonsmokers. This was in agreement with the findings of previous studies by Haffaje *et al.*[25] and Meyerov[3] observing that there could be an increase in cellular and molecular activity due to increased periodontal inflammation with the increase in probing pocket depth. Although a moderately significant temperature difference was found at probing pocket depths of 3, 4, and 5 mm, the difference was not statistically significant at probing pocket depths of 6 mm and more, possibly due to the relatively small number of pockets.

The mean sublingual temperature for all the subjects in this study was 36.3°C; for smokers, it was 36.6°C and for nonsmokers 36.1°C. When the sublingual temperature was compared for the smokers and nonsmokers, a difference was apparent (0.5°C) with smokers showing a warmer mean value. This difference in sublingual temperatures between smokers and nonsmokers, although difficult to explain, is in accordance with previous investigations by Peter. F. Fedi *et al.*,[10] Haffajee *et al.*,[16,25] and Dinsdale *et al.*[8]

In general, the subgingival site temperatures were cooler than the sublingual temperatures, except in a few markedly inflamed sites. The mean subgingival site temperatures for healthy and diseased sites in each group were recorded. Diseased sites were approximately 2.5°C warmer than the healthy sites. The mean subgingival site temperature between smokers and nonsmokers was significantly different, being approximately 0.4°C warmer in smokers compared to nonsmokers. When healthy sites were compared between the smokers and nonsmokers, a significant difference was found with smokers showing a warmer mean site temperature of approximately 0.6°C. For diseased sites, the smokers had a mean subgingival temperature of 0.2°C higher than nonsmokers. The findings of this study reveal a definite temperature difference between healthy and diseased sites of smokers and nonsmokers as suggested by Compton and Walter *et al.*[18,15] and Dinsdale *et al.*[8] Kung *et al.*[11,12,26] suggested that the increase in the temperature in the diseased sites can be an expression of the complex cellular, molecular, and metabolic events occurring during an inflammatory response. This means that the increase in cellular activity generates heat which warms the blood passing through the site, thereby resulting in an increase in temperature within a periodontal pocket.

The mean temperature differential was more for smokers in diseased sites compared to nonsmokers. This is because there were more diseased sites in smokers in this study; thus, the mean subgingival temperature increased resulting in a higher temperature differential. The results of the present study are in agreement with previous studies on temperature differential by Fedi and Killoy *et al.*,[27] Kung *et al.*[26]

When healthy sites were compared, smokers showed a mean temperature differential of 0.1°C lower than nonsmokers, which could be due to fewer diseased sites in nonsmokers. When diseased sites were compared, nonsmokers showed a mean temperature differential of 0.2°C lower than smokers. The above findings are almost in accordance with the findings of Dinsdale *et al.*[8] and Trikilis *et al.*[7] They also suggested that mean temperature differential was taken to reduce subject-to-subject variation; and considering the difference in sublingual temperature between two groups, it was more valid to compare temperature differential. The increase in site temperature can be an expression of the complex cellular, molecular, and metabolic activities occurring during the inflammatory process. However, the value of subgingival temperature as a diagnostic test for an active periodontal disease can be defined only through further longitudinal studies.

Conclusion

The present study aimed at comparing subgingival temperatures of healthy and diseased periodontal sites between smokers and nonsmokers using a modified thermometer. Subgingival temperature measurement could be a reliable assessment of periodontal inflammation and disease activity when the usual clinical signs are unreliable. Further modification in the length and thickness of the sensor and producing markings (mm) on the sensor of the digital thermometer may facilitate a more accurate recording of the subgingival temperature in the pockets of more than 5 mm. Measuring the subgingival temperatures with these improved thermometer sensors can serve as a fast screening process for the assessment of periodontal disease activity. Temperature measurements have been found to reflect clinically defined conditions, suggesting that subgingival temperature measurements may have unexplored potentials in diagnosing and monitoring the periodontal condition. Primary care physicians and oral health professionals should have a modified thermometer as a reliable subgingival temperature measurement tool. A rise in the gingival temperature is the earliest sign of inflammation; the physicians and dental surgeons should always consider it as a primary health-care measure. More extensive studies will further define the importance of the subgingival temperature as a diagnostic test for active periodontal diseases.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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