

## Subgingival Temperature in Health and Disease—A Comparative Study

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### **Abstract:**

**Aim:** Of all the signs of inflammation rise of temperature is the most objective and reproducible. But this sign is rarely used due to non-availability of an instrument which is easily available and also accurate. In this present study an attempt was made to devise such an instrument. So in this present study an indigenously prepared thermocouple was used to determine the subgingival temperature in healthy and diseased periodontal sites and to compare the same within various sites and regions among and within healthy and diseased periodontal sites and show that rise in subgingival temperature is an indicator of periodontal disease.

**Materials and Methods:** 60 male subjects were selected within the age group of 19-54yrs. They were classified into STUDY GROUP which included subjects with periodontal sites having probing depth of 5mm or more with bleeding on probing and CONTROL GROUP included subjects with periodontal sites less than or equal to 4mm and which did not bleed upon probing. Only the central incisors, canine and first molars of any one quadrant of the maxillary and mandibular arch were considered. A copper-constantan thermocouple glued to a plastic probe was used to determine the potential difference between the thermocouple in periodontal site and ice. The potential difference is directly proportional to temperature and thus the temperature was determined by using a reference temperature chart or an equation. The statistical package SPSS PC+ version 4.0 was used for statistical analysis. Mean and standard deviation were estimated from the sample for each group. The mean values were compared by student's independent t-test/ student's paired t-test appropriately. In the present study,  $p < 0.05$  was considered as the level of significance.

**Results:** Subgingival temperature in CONTROL group shows higher temperature difference from the sublingual temperature indicating cooler sites than STUDY group which showed smaller temperature difference.

- In CONTROL group the subgingival temperature of the mandibular sites were higher than the corresponding maxillary sites and there was a characteristic antero-posterior gradient with posterior sites being warmer than the anterior sites. In the STUDY group also the posterior sites were warmer than anterior sites.
- Analysis of subgingival temperature showed that the diseased sites have higher temperatures than anatomically equivalent healthy sites ( $p < 0.0001$ )

**Conclusion:** The results show that rise in temperature is an indicator of inflammatory activity associated with periodontal disease. The specially designed instrument was capable of detecting the temperatures in disease related sites and normal sites despite its limitations.

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### **I. Introduction**

The first information about inflammation dates back to about 1550 B.C. where in the Edwin Smith Papyrus[1], an Egyptian papyrus found in a tomb near Thebes, the description of inflammation was given.

Cornelius Celsius, a non-medico Roman living in the first century was the first to describe the features of inflammation- redness, swelling, heat and pain. Of all the cardinal signs of inflammation, temperature is the only one which can be measured quantitatively and objectively. Furthermore, periodontitis is a chronic inflammatory disease and should manifest an increase in temperature in diseased sites. Clinical fact that inflammation manifests in rubor, tumor, dolor and calor formed the concept for this study.

A temperature-sensitive probe was developed to detect periodontal pocket temperature, the thermocouple probe was designed with low thermal conductivity to avoid significant thermal disturbances in the measured area.[4]

Using the indigenously devised thermocouple probe the present study was done to determine the subgingival temperature in healthy and diseased periodontal sites. With the measurements thus obtained we compared the temperatures in the maxillary and mandibular sites and among healthy and diseased sites.

## **II. Materials and Methods**

60 patients were selected from those attending the outpatient department of Tamilnadu Government Dental College and Hospital, Chennai-03. The study was done in 2002 and had approval from the ethical committee of Tamilnadu Government dental College & hospital. This was a comparative study where thirty patients who had clinical and radiographic evidence of periodontitis were taken under the STUDY GROUP. The other thirty who were normal both clinically and radiographically in their periodontal health were taken as CONTROL GROUP after informed consent was obtained from them. The study was done for a period of six months.

In the present study only male subjects were selected to avoid variation in body temperature which might have occurred in females during pregnancy, menstruation, ovulation (Mohd. Yunis S.B., Vandana K.L., 2000)[7]. Mukherjee (1978)[8] also found a statistically significant difference in the sublingual temperature between the male and female subjects.

Maeda et al (1979)[9] noticed there was a difference in oral temperature which was statistically significant between very young and very old males, so the age group selected was 19 – 54 yrs in the present study. The patients selected for the study had no history of drug intake for at least 3 months before the study. Patients selected did not also have any periodontal treatment for the past 3 months. All patients were free from known systemic diseases

Smokers were excluded in this present study, as according to Haber 1993[10], Grossi et al 1994[11], 1995[12], tough smokers show more attachment loss than non-smokers, they show less bleeding on probing. Further when the sublingual temperatures of smokers and non-smokers were compared an apparent difference was found with the smokers showing a warmer mean value ( Dinsdale et al)[3]

## **III. Method**

A complete periodontal examination was undertaken using a William's periodontal probe at six sites around each tooth. The presence or absence of bleeding was also noted using a pressure sensitive probe (VIVACARE TPS) [fig no. ] in all the sites around each tooth.

Patients were refrained from eating or drinking for at least 30 minutes prior to taking any temperature measurements. In addition, none of the patients had brushed, rinsed their teeth in the preceding 30 minutes (Dinsdale et al)[3]

A copper-constantan thermocouple (Type T) glued to a plastic probe was used to make temperature measurements. [fig.no. ] The thermocouple was attached to the Digital Multivoltmeter where readings were given as voltage[2]. [fig. no. ]

The plastic probe was used to obviate any error of heat conduction (Meyerov et al)[4] which might have occurred with a metal probe. The plastic probe has a green color coding till 3mm reading, a red ring at 5mm and red band from 7-10mm.

For every patient the measurement of sublingual temperature was first made. The sublingual reference temperature was taken by placing the probe tip in the lingual sulcus adjacent to the last molar tooth, with the depth marking parallel to the long axis of the tooth (Dinsdale et al)[3] [fig.no. ].

Measurements of temperature of gingival sulci were taken from the mesiolingual / mesiopalatal areas of the central incisors, canines and first molars of the maxillary and mandibular regions. [fig.no. ] In this present study, central incisors, canines and I molars of any quadrant of both the maxillary and mandibular jaws were assessed and temperature measurements were made in the mesiobuccal/labial and mesiolingual/palatal sites of the included teeth. [fig no. ] The above teeth were selected to show an antero – posterior gradient of temperature and to compare the differences in temperature in the maxillary and mandibular periodontal sites. Mukherjee (1978)[8] used the same key teeth for the measurement of subgingival temperature in healthy gingival sulci, using thermistor probe.

Only one quadrant of both maxillary and mandibular arch was taken in this study as the left and right side showed no difference in temperature gradient as confirmed by Kung et al (1990)[14]. Measurements of temperature of gingival sulci were taken from the mesiobuccal and mesiopalatal areas of the central incisors, canines and first molars of the maxillary and mandibular regions. Thus, a total of 12 measurements were made in each patient. In case of absence of tooth measurements were taken from corresponding area on other half of the jaw of the same patient.

A temperature difference between any two points in a normal metal will result in an electrostatic potential difference if no electric current is allowed to flow between those two points. This potential difference is proportional to the temperature difference  $T_1 - T_2$ . [2]

The potential that is measured is dependent on temperature ( $T_1 - T_2$ ) and not the actual values  $T_1$  &  $T_2$ . Therefore if one of those temperatures ( $T_2$ ) is fixed at a known value, it is possible to make accurate temperature measurements.

An easy way to fix the temperature of  $T_2$ , is to have it in an ice water bath; as long as ice is present, and in equilibrium with the water, the temperature of the water will be  $0^\circ\text{C}$ .

The thermocouple leads in ice bath are connected to the Digital Multivoltmeter by lengths of wire. These lengths of wire have to be of same type of metal. The potential of the system is the sum of the individual potentials that arises throughout the system.

Starting at the digital multivoltmeter there is a potential  $V_0$  that arises through the first lead, going from room temperature to  $0^\circ\text{C}$ . There is a potential ( $V_1+V_2$ ) of the thermocouple and the potential that arises within the second Digital Multivoltmeter lead, as it goes from  $0^\circ\text{C}$  to room temperature  $V_3$ . If the strips of wire that attach the Digital Multivoltmeter to the thermocouple are the same, then the potential  $V_0$  cancels out the potential  $V_3$ .

The Digital Multivoltmeter then only displays the potential ( $V_1+V_2$ ) which is what is required to make the temperature measurement. The size of the thermocouple wire is also important. When sensitivity is the primary concern, smaller sizes should be used.[2]

Since the effect of conduction of heat from the hot end of the thermocouple must be minimized, the thermocouple has to have sufficient length. Unless there is sufficient immersion, readings will be low. It is suggested the thermocouple be immersed for a minimum distance equivalent to four times the outside diameter of a tube or well.[2]

#### **IV. Calculation of Temperature**

The thermocouple used is of type T which is one of the oldest and most popular thermocouple for determining temperature within the range from about  $370^\circ\text{C}$  down to the triple point of neon ( $-248.593^\circ\text{C}$ ). Its positive thermoelement is typically copper of high electrical conductivity and low oxygen content.

The multivoltage reading is converted to temperature by referring the chart.[given at the back (Appendix)]. The readings thus derived were tabulated and statistically evaluated.

#### **V. Statistical Analysis**

The statistical package SPSS PC+ version 4.0 was used for statistical analysis. Mean and standard deviation were estimated from the sample for each group. The mean values were compared by student's independent t-test/ student's paired t-test appropriately. In the present study,  $p < 0.05$  was considered as the level of significance.

#### **VI. Results**

In this present study all subjects had a body (sublingual) temperature within the physiological range ( $35.8-37.8^\circ\text{C}$ )

The table 1[Bar graph 1,1(a),2,2(a)] shows mean temperatures in CONTROL and STUDY group. The lowest mean temperature in CONTROL group is  $32.12 \pm 0.51^\circ\text{C}$  was in the maxillary buccal/labial region and highest of  $34.40 \pm 0.44^\circ\text{C}$  in the mandibular lingual region. In the STUDY group the highest mean temperature was  $35.42 \pm 0.46^\circ\text{C}$  and the lowest temperature was  $34.11 \pm 0.72^\circ\text{C}$  in the mandibular buccal region.

Table 2 [Bar graph 3 & 4] shows comparison of temperatures of sites in the maxillary region to the corresponding sites in the mandibular region. Though it is statistically significant in the CONTROL group such significance was not seen while measuring the mean temperatures in the STUDY group.

Table 3[Bar graph 5 & 6] shows the comparison of temperature of mean subgingival temperature within maxillary and mandibular sites between CONTROL group and the STUDY group. All the comparisons were statistically significant, stating that the temperature in STUDY (DISEASE) group is greater than in CONTROL group ( $p < 0.0001$ )

Average subgingival temperatures of the teeth involved in the study were calculated by taking the means of the buccal/labial and palatal/lingual subgingival temperatures. In table 4 [Bar graph 7] the average temperatures were compared within each group. Mean temperatures in the mandibular sites are significantly higher than the mean temperatures in the maxillary sites in CONTROL group ( $p < 0.001$ ). However, there is no significant difference in the mean temperature between maxillary and mandibular sites in the STUDY group ( $p > 0.05$ ).

Table 5 [Bar graph 8 & 8(a)] shows the comparison of average temperature within maxillary and mandibular sites between CONTROL and STUDY groups. The results show that the mean temperature in the STUDY group is significantly higher than the mean temperature in CONTROL group for both the maxillary and mandibular sites ( $p < 0.0001$ ).

In table 6, the mean temperatures of the central incisors and canines put together and average was taken as the mean temperature of the anterior region and the mean temperature of first molar was taken as the average temperature of the posterior. These when compared showed a significant difference between anterior and

posterior regions ( $p < 0.0001$ ) and there is a gradual rise in temperature from the anterior to posterior region, creating an antero- posterior gradient. [6]

## VII. Discussion

In the pathogenesis of periodontal diseases we see vasculitis, transition of junctional epithelium to pocket epithelium and changes in connective tissue and bone resorption are the basic changes seen during the initial, early and advanced stages, respectively. The characteristics of vasculitis include color, temperature, blood flow and bleeding. In healthy tissue the difference between the temperature of the gingiva and the core temperature (sublingual) were of the order of  $0.2^{\circ}\text{C}$ ; in inflamed tissue this temperature differential approached zero (Page R.C., 1979)[6].

Based upon the hypothesis of thermal gradient[6] between clinically healthy and inflamed gingiva, temperature measurements have been considered for application in periodontal diagnosis.

The use of bleeding as an indicator of early gingival pathology has the clinical advantage that it is more objective. Bleeding is either present or absent, whereas color changes and degree of inflammation require subjective estimation by the examiner. Controlled insertion pressures with clear delineation of the probing technique can make bleeding evaluations reproducible and objective ( Meitner et al 1979)[13]. Thus bleeding on probing was taken as a parameter for selection of patients in the present study.

Various devices have been used to record subgingival temperature. Some of the devices used included PERIO-TEMP (Haffajee 1992 [15], [16],[17], Niederman R. 1993[18]), thermistor probe digital thermometer (Ng G.C.1978[19]), copper- nickel thermocouple connected to digital thermometer (Meyerov 1991[20],[4]), microprobe thermocouple digital thermometer (Holthius 1981[21]), copper – constantin thermocouple in a Teflon tube using and amplifier equipped with an electronic circuit where electric current difference between water bath and periodontal site was determined (Tanaka M. et al[22])

In the present study though the equipment used was cumbersome, it was very economical and also the temperature measurements were near accurate. Further studies are needed to devise equipment far less cumbersome.

Whether in health or in disease the subgingival temperature is always less than the sublingual temperature which is concurrence with all studies done on subgingival temperature like Haffajee (1992) [15], [16], [17], Kung (1990) [14]).

The differences in subgingival temperature between periodontally healthy and diseased sites were statistically significant which has been seen in several other studies like Mohd. Yunis S.B., Vnadana K.L.(2000)[7],Mukherjee (1978)[8]&(1981)[23].

In conclusion the results of the study show that the healthy sites are relatively cooler than diseased sites. There is an antero –posterior gradient both in health and in disease with the posterior mandibular sites being warmer. The mandibular sites are warmer than the maxillary sites in health, but the difference in temperature between the maxillary and mandibular sites in disease is not significant. Though the device used for temperature measurement was cumbersome equipment, the temperature changes correlated with disease activity. Hence temperature is a more reproducible method for diagnosing periodontal disease activity. Thus the need is for designing a technologically advanced equipment for easy measurement of subgingival temperature which is also economical.

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Appendix

TABLE A8.2.1. Type T thermocouples—temperature (°C) as a function of thermoelectric voltage; reference junctions at 0°C—Continued

.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	mV
TEMPERATURES IN DEGREES C (1975 1988)											
0.00	0.26	0.52	0.77	1.03	1.29	1.55	1.80	2.06	2.32	2.58	0.00
2.58	2.83	3.09	3.35	3.60	3.86	4.12	4.37	4.63	4.88	5.14	0.10
5.14	5.39	5.65	5.91	6.16	6.42	6.67	6.93	7.18	7.44	7.69	0.20
7.69	7.95	8.20	8.45	8.71	8.96	9.22	9.47	9.73	9.98	10.23	0.30
10.23	10.48	10.74	10.99	11.24	11.50	11.75	12.00	12.25	12.51	12.76	0.40
12.76	13.01	13.26	13.51	13.76	14.02	14.27	14.52	14.77	15.02	15.27	0.50
15.27	15.52	15.77	16.02	16.27	16.52	16.77	17.02	17.27	17.52	17.77	0.60
17.77	18.02	18.27	18.52	18.77	19.02	19.27	19.52	19.77	20.02	20.26	0.70
20.26	20.51	20.76	21.01	21.25	21.50	21.75	22.00	22.24	22.49	22.74	0.80
22.74	22.99	23.23	23.48	23.73	23.97	24.22	24.47	24.71	24.96	25.20	0.90
25.20	25.45	25.69	25.94	26.19	26.43	26.68	26.92	27.17	27.41	27.65	1.00
27.65	27.90	28.14	28.39	28.63	28.88	29.12	29.36	29.61	29.85	30.09	1.10
30.09	30.34	30.58	30.82	31.07	31.31	31.55	31.79	32.04	32.28	32.52	1.20
32.52	32.76	33.00	33.25	33.49	33.73	33.97	34.21	34.45	34.69	34.94	1.30
34.94	35.18	35.42	35.66	35.90	36.14	36.38	36.62	36.86	37.10	37.34	1.40
37.34	37.58	37.82	38.06	38.30	38.54	38.77	39.01	39.25	39.49	39.73	1.50
39.73	39.97	40.21	40.44	40.68	40.92	41.16	41.40	41.63	41.87	42.11	1.60
42.11	42.35	42.59	42.82	43.06	43.30	43.53	43.77	44.00	44.24	44.48	1.70
44.48	44.71	44.95	45.18	45.42	45.65	45.89	46.11	46.35	46.58	46.82	1.80
46.82	47.05	47.29	47.52	47.75	48.00	48.24	48.47	48.71	48.94	49.18	1.90
49.18	49.41	49.65	49.88	50.11	50.35	50.58	50.81	51.05	51.28	51.51	2.00
51.51	51.74	51.98	52.21	52.44	52.67	52.91	53.14	53.37	53.60	53.84	2.10
53.84	54.07	54.30	54.53	54.76	54.99	55.22	55.45	55.68	55.92	56.15	2.20
56.15	56.38	56.61	56.84	57.07	57.30	57.53	57.76	57.99	58.22	58.45	2.30
58.45	58.68	58.91	59.14	59.37	59.60	59.83	60.06	60.29	60.52	60.74	2.40
60.74	60.97	61.20	61.43	61.66	61.89	62.12	62.34	62.57	62.80	63.03	2.50
63.03	63.25	63.48	63.71	63.94	64.16	64.39	64.62	64.85	65.07	65.30	2.60
65.30	65.52	65.75	65.98	66.21	66.43	66.66	66.89	67.11	67.34	67.56	2.70
67.56	67.79	68.02	68.24	68.47	68.69	68.92	69.14	69.37	69.59	69.82	2.80
69.82	70.04	70.27	70.49	70.72	70.94	71.17	71.39	71.61	71.84	72.06	2.90
72.06	72.29	72.51	72.73	72.96	73.18	73.41	73.63	73.85	74.08	74.30	3.00
74.30	74.52	74.74	74.97	75.19	75.41	75.63	75.85	76.08	76.30	76.52	3.10
76.52	76.75	76.97	77.19	77.41	77.64	77.86	78.08	78.30	78.52	78.74	3.20
78.74	78.97	79.19	79.41	79.63	79.85	80.07	80.29	80.51	80.73	80.95	3.30
80.95	81.17	81.39	81.61	81.84	82.06	82.28	82.50	82.72	82.94	83.16	3.40
83.16	83.38	83.60	83.82	84.04	84.26	84.48	84.70	84.92	85.14	85.36	3.50
85.36	85.58	85.80	86.02	86.24	86.46	86.68	86.90	87.12	87.34	87.56	3.60
87.56	87.78	88.00	88.22	88.44	88.66	88.88	89.10	89.32	89.54	89.76	3.70
89.76	89.98	90.20	90.42	90.64	90.86	91.08	91.30	91.52	91.74	91.96	3.80
91.96	92.18	92.40	92.62	92.84	93.06	93.28	93.50	93.72	93.94	94.16	3.90
94.16	94.38	94.60	94.82	95.04	95.26	95.48	95.70	95.92	96.14	96.36	4.00
96.36	96.58	96.80	97.02	97.24	97.46	97.68	97.90	98.12	98.34	98.56	4.10
98.56	98.78	99.00	99.22	99.44	99.66	99.88	100.10	100.32	100.54	100.76	4.20
100.76	100.98	101.20	101.42	101.64	101.86	102.08	102.30	102.52	102.74	102.96	4.30
102.96	103.18	103.40	103.62	103.84	104.06	104.28	104.50	104.72	104.94	105.16	4.40
105.16	105.38	105.60	105.82	106.04	106.26	106.48	106.70	106.92	107.14	107.36	4.50
107.36	107.58	107.80	108.02	108.24	108.46	108.68	108.90	109.12	109.34	109.56	4.60
109.56	109.78	110.00	110.22	110.44	110.66	110.88	111.10	111.32	111.54	111.76	4.70
111.76	111.98	112.20	112.42	112.64	112.86	113.08	113.30	113.52	113.74	113.96	4.80
113.96	114.18	114.40	114.62	114.84	115.06	115.28	115.50	115.72	115.94	116.16	4.90
116.16	116.38	116.60	116.82	117.04	117.26	117.48	117.70	117.92	118.14	118.36	5.00
118.36	118.58	118.80	119.02	119.24	119.46	119.68	119.90	120.12	120.34	120.56	5.10
120.56	120.78	121.00	121.22	121.44	121.66	121.88	122.10	122.32	122.54	122.76	5.20
122.76	122.98	123.20	123.42	123.64	123.86	124.08	124.30	124.52	124.74	124.96	5.30
124.96	125.18	125.40	125.62	125.84	126.06	126.28	126.50	126.72	126.94	127.16	5.40
127.16	127.38	127.60	127.82	128.04	128.26	128.48	128.70	128.92	129.14	129.36	5.50
129.36	129.58	129.80	130.02	130.24	130.46	130.68	130.90	131.12	131.34	131.56	5.60
131.56	131.78	132.00	132.22	132.44	132.66	132.88	133.10	133.32	133.54	133.76	5.70
133.76	133.98	134.20	134.42	134.64	134.86	135.08	135.30	135.52	135.74	135.96	5.80
135.96	136.18	136.40	136.62	136.84	137.06	137.28	137.50	137.72	137.94	138.16	5.90
138.16	138.38	138.60	138.82	139.04	139.26	139.48	139.70	139.92	140.14	140.36	6.00
140.36	140.58	140.80	141.02	141.24	141.46	141.68	141.90	142.12	142.34	142.56	6.10
142.56	142.78	143.00	143.22	143.44	143.66	143.88	144.10	144.32	144.54	144.76	6.20
144.76	144.98	145.20	145.42	145.64	145.86	146.08	146.30	146.52	146.74	146.96	6.30
146.96	147.18	147.40	147.62	147.84	148.06	148.28	148.50	148.72	148.94	149.16	6.40
149.16	149.38	149.60	149.82	150.04	150.26	150.48	150.70	150.92	151.14	151.36	6.50
151.36	151.58	151.80	152.02	152.24	152.46	152.68	152.90	153.12	153.34	153.56	6.60
153.56	153.78	154.00	154.22	154.44	154.66	154.88	155.10	155.32	155.54	155.76	6.70
155.76	155.98	156.20	156.42	156.64	156.86	157.08	157.30	157.52	157.74	157.96	6.80
157.96	158.18	158.40	158.62	158.84	159.06	159.28	159.50	159.72	159.94	160.16	6.90
160.16	160.38	160.60	160.82	161.04	161.26	161.48	161.70	161.92	162.14	162.36	7.00
162.36	162.58	162.80	163.02	163.24	163.46	163.68	163.90	164.12	164.34	164.56	7.10
164.56	164.78	165.00	165.22	165.44	165.66	165.88	166.10	166.32	166.54	166.76	7.20
166.76	166.98	167.20	167.42	167.64	167.86	168.08	168.30	168.52	168.74	168.96	7.30
168.96	169.18	169.40	169.62	169.84	170.06	170.28	170.50	170.72	170.94	171.16	7.40
171.16	171.38	171.60	171.82	172.04	172.26	172.48	172.70	172.92	173.14	173.36	7.50
173.36	173.58	173.80	174.02	174.24	174.46	174.68	174.90	175.12	175.34	175.56	7.60
175.56	175.78	176.00	176.22	176.44	176.66	176.88	177.10	177.32	177.54	177.76	7.70
177.76	177.98	178.20	178.42	178.64	178.86						