The Relationship of Two-Hour Blood Glucose to Oral Signs (Dental Findings)

P. MOLLER, D.M.D. and E. CHERASKIN, M.D., D.M.D.

Reprinted from
THE NEW YORK JOURNAL OF DENTISTRY
Vol. 31, No. 1, pp. 5-14, January 1961

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

The Relationship of Two-Hour Blood Glucose to Oral Signs (Dental Findings)*

P. MOLLER, D.M.D.** and E. CHERASKIN, M.D., D.M.D.***, Birmingham, Alabama

INTRODUCTION

The implication is present in the literature that clinical tooth mobility and tooth loss are common findings in the diabetic patient. Further implied is that the relationship is linear. In other words, the more pronounced the diabetic state (the higher the blood glucose), the more severe the tooth mobility, the greater the incidence of tooth loss.

A report has already been released[1] in which the relationship of these two dental signs (clinical tooth mobility and tooth loss) to the *fasting* blood true glucose in a group of 100 routine dental patients has been analyzed. Shown in that report was that there are statistically significant relationships between tooth loss and fasting blood glucose groups.

This report will consider the relationship of these same two signs to the *two-hour* blood *true* glucose as determined during the glucose tolerance testing of a group of 100 routine dental patients.

REVIEW OF THE LITERATURE

Published material is available regarding the relationship between diabetes mellitus and: 1) *clinical tooth mobility,* and 2) *tooth loss.*

Clinical Tooth Mobility: Frequent mention is made of this complaint in the literature.[2-6] However, none of these reports attempts to quantitate tooth mobility with carbohydrate imbalance. Sheridan et al[7] observed clinical tooth mobility in 75 per cent of their dental patients with diabetes mellitus. In contrast, 38 per cent of their nondiabetic group were found to have clinical tooth mobility. Cheraskin and Moller[8] have demonstrated significant relationships between the glucose tolerance pattern and clinical tooth mobility. Specifically, the fasting, one, two, and three hour true glucose levels were higher in those patients with clinical tooth mobility compared with those without tooth mobility.

Tooth Loss: Lovestedt and Austin[9] reported a greater incidence of tooth loss in diabetic patients than in their observed nondiabetic population. Barach[10] also observed a greater tooth loss pattern among 200 diabetic patients in contrast with an examination of the total number of teeth in various age groups among 12,000 presumably healthy individuals. Sheridan et al[7] in their study of 100 routine dental patients, found a mean of 18.19 teeth in diabetic patients with a standard deviation of 9.70 contrasted with 21.21 teeth in presumably healthy persons with a standard deviation of 8.32. In other words, the consensus is that tooth loss is associated with the diabetic state.

Method of Investigation: One hundred dental patients were studied in the Section on Oral Medicine at the University of Alabama School of Dentistry. As far as possible, the subjects were selected at random. Table 1 shows the age distribution of the group. It can be observed that the pattern approaches a typical unimodal curve. Included in this study were 22 males and 78 females.

Each subject was carefully examined regarding possible clinical tooth mobility. The scoring was made on the basis of a three-point scale. If no tooth mobility was demonstrated, zero was assigned. When the teeth showed mobility less than 1 mm., then one was recorded.

* This investigation was supported in part by a traineeship grant (2G-15) from the Epidemiology and Biometry Section, Public Health Service and U. S. Army Contract No. DA-49-193-MD-2059.

** Fellow in Oral Medicine, University of Alabama School of Dentistry, Birmingham, Alabama.

*** Professor and Chairman, Section on Oral Medicine, University of Alabama School of Dentistry, Birmingham, Alabama.

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

Table 1—Age Distribution

age group	*total number of patients*
0- 9	1
10-19	9
20-29	19
30-39	27
40-49	19
50-59	17
60-69	8
total	100

Two was utilized to indicate tooth mobility greater than 1mm. Edentulous subjects were assigned a score of three. Patients without any teeth were included in the clinical tooth mobility analysis, considering total absence of teeth as the extreme in tooth mobility. An analysis was also made of clinical tooth mobility excluding edentulous subjects, and no significant difference was observed between the results obtained from these two scoring systems. Therefore, in the interest of space conservation, in this study only the analysis including the edentulous subjects will be reported. Also, the number of teeth clinically evident was counted. For this report, a scoring based on the three-point scale was designed. If 25 to 32 teeth were clinically evident, zero was assigned. When the number of teeth was 20 to 25, then one was recorded. Two was utilized to indicate that 10 to 19 teeth were observed. Three was assigned for edentulous subjects. Realizing the crudeness of this scoring system, an analysis, based on the actual number of teeth lost, was also made. Again no significant difference was observed between the results obtained from these two scoring systems. Therefore, in the interest of simplifying the computations in this report, the scoring system based on the three-point scale was employed.

A true glucose tolerance test was performed on each patient according to the methods of Somogyi[11, 12] and Nelson.[13] No preparatory diet was recommended except for complete fasting for twelve hours prior to the laboratory examination. Complete details regarding the method of investigation are available in the publication by Sheridan et al.[7] For

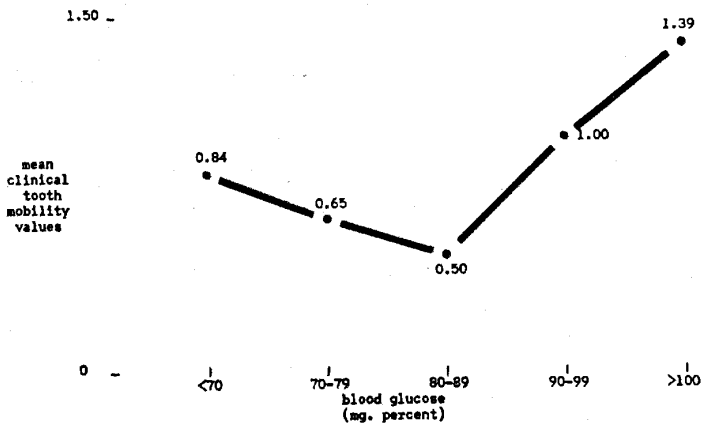

Fig. 1—Relationship of two-hour blood glucose to clinical tooth mobility (100 routine dental patients).

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

this study, only the information derived from the *two-hour* blood glucose measurements was utilized.

RESULTS

The two-hour blood glucose determinations will be considered in the light of: 1) *single signs,* and 2) *combination of the single signs.*

Single Signs: An analysis of the data will be offered for: 1) *clinical tooth mobility,* and 2) *tooth loss.*

Clinical Tooth Mobility: This particular sign will be discussed in terms of: 1) *mean scores,* 2) *coefficients of variation,* and 3) *statistical significance.*

Mean Scores: It appears from Figure 1 that the relationship between two-hour blood glucose and clinical tooth mobility is parabolic. In other words, tooth mobility is least with two-hour blood glucose levels in the 80-89 mg. per cent range. As the two-hour blood glucose decreases and increases, clinical tooth mobility also increases.

Coefficients of Variation: Table 2 shows the range of coefficients of variation for the various two-hour blood glucose groups. It is noteworthy that the greatest coefficient of variation occurred in the <70 mg. per cent group. It is also of interest that the least coefficient of variation occurred in those subjects with a two-hour blood glucose level greater than 100 mg. per cent.

Statistical Significance: Table 2 also shows no statistically significant difference between any of the two-hour blood glucose groups. However, an analysis between the 80-89 mg. per cent group and the >100 mg. per cent group discloses a P <.001.

Tooth Loss: This particular dental sign will be discussed in terms of: 1) *mean scores,* 2) *coefficients of variation,* and 3) *statistical significance.*

Mean Scores: It appears from Figure 2 that the relationship between two-hour blood glucose and the incidence of tooth loss resembles a parabola. However, the pattern is not as convincing as previously shown with respect to clinical tooth mobility. The incidence of tooth loss appears to be least with two-hour blood glucose levels in the 80-89 mg. per cent group. As the two-hour blood glucose increases and similarly, though not as marked, as it decreases, the mean tooth loss values also increase.

Coefficients of Variation: Table 3 shows the range of coefficients of variation for the various two-hour blood glucose groups. The greatest coefficient of variation occurred in the <70 mg. per

Table 2—Relationships of Two-hour Glucose to Clinical Tooth Mobility

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
mean clinical tooth mobility-score	.84	.65	.50	1.00	1.39
standard deviation	1.164	.813	.632	1.155	1.031
coefficient of variation	138.57	125.08	126.40	115.50	74.17
mean difference	.19	.15	.50	.39	
standard error of difference	.322	.241	.464	.467	
observed t value	.5900	.6224	1.0775	.8351	
degrees of freedom	37	34	21	43	
P	.500	.500	>.200	>.400	

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

Table 3—Relationship of Two-hour Blood Glucose to Tooth Loss

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
mean tooth loss score	.74	.85	.68	1.57	1.19
standard deviation	1.147	.988	.873	1.134	1.110
coefficient of variation	155.00	116.24	128.38	72.23	93.28
mean difference	.11	.17	.89	.38	
standard error of difference	.344	.310	.481	.465	
observed t value	.3197	.5481	1.8503	.8172	
degrees of freedom	37	34	21	43	
P	.500	.500	>.050	>.400	

Table 4—Relationship of Two-hour Blood Glucose to Clinical Tooth Mobility and Tooth Loss

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
mean tooth mobility and number of teeth scores	1.58	1.45	1.18	2.57	2.60
standard deviation	2.219	1.701	1.047	1.988	1.897
coefficient of variation	140.44	117.31	88.73	77.35	72.96
mean difference	.13	.27	1.39	.03	
standard error of difference	.636	.463	.794	.811	
observed t value	.2044	.5831	1.7506	.0369	
degrees of freedom	37	34	21	43	
P	.500	.500	>.050	.500	

Table 5—Comparison of Mean Scores

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
clinical tooth mobility	.84	.65	*.50*	1.00	1.39
tooth loss	.74	.85	*.68*	1.57	1.19
clinical tooth mobility and tooth loss	1.58	1.45	*1.18*	2.57	2.60

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

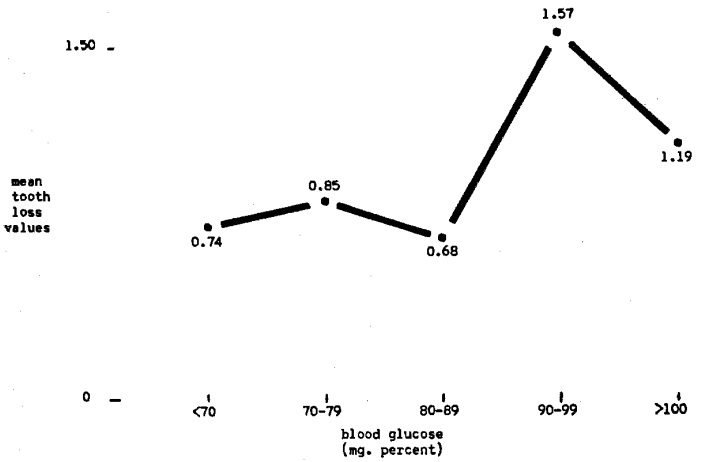

Fig. 2—Relationship of two-hour blood glucose to tooth loss (100 routine dental patients).

cent group, as was also observed in the tooth mobility analysis.

Statistical Significance: Table 3 also shows no statistically significant difference between any of the two-hour blood glucose groups.

COMBINATION OF SINGLE FINDINGS

An analysis of the data will be offered for clinical tooth mobility and tooth loss.

Clinical Tooth Mobility and Tooth Loss: The combination of these two dental signs will be discussed in terms of: 1) *mean scores,* 2) *coefficients of variation,* and 3) *statistical significance.*

Mean Scores: It appears from Figure 3 that the relationship between two-hour blood glucose and the presence of these two dental signs is parabolic. In other words, clinical tooth mobility and tooth loss are least with two-hour blood glucose in the 80-89 mg. per cent range. As the two-hour blood glucose decreases or increases, the combination of clinical tooth mobility and tooth loss also increases.

Coefficients of Variation: Table 4 shows that the least coefficient of variation was observed in the >100 mg. per cent blood group. In other words, the individual scores cluster more closely about the mean as one approaches hyperglycemia.

Statistical Significance: Table 4 also shows no statistically significant difference between the blood glucose groups. However, comparison of the 80-89 and >100 mg. per cent groups disclosed a P of <.001.

DISCUSSION

The data will be discussed in the following fashion: 1) *mean scores,* 2) *coefficients of variation,* and 3) *probability values.* Because of the close correlation between age versus glucose levels and oral signs and age, the age factor will be analyzed in terms of two-hour blood glucose and oral signs.

Mean Scores: An analysis of the mean score values for the two dental signs independently and in their combination points up the fact that the patterns are always parabolic. However, it appears that the parabolic picture is more clearcut with the combination of the two signs and when clinical tooth mobility is analyzed alone than with tooth loss independently. These data would tend to indicate that there is a

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

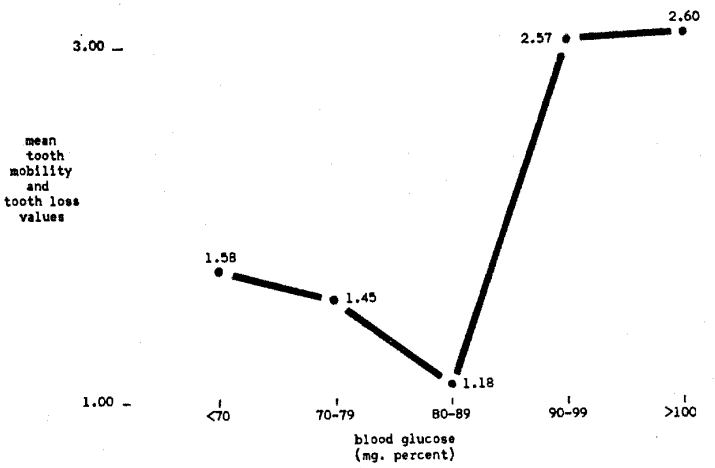

Fig. 3—Relationship of two-hour blood glucose to tooth mobility and tooth loss (100 routine dental patients).

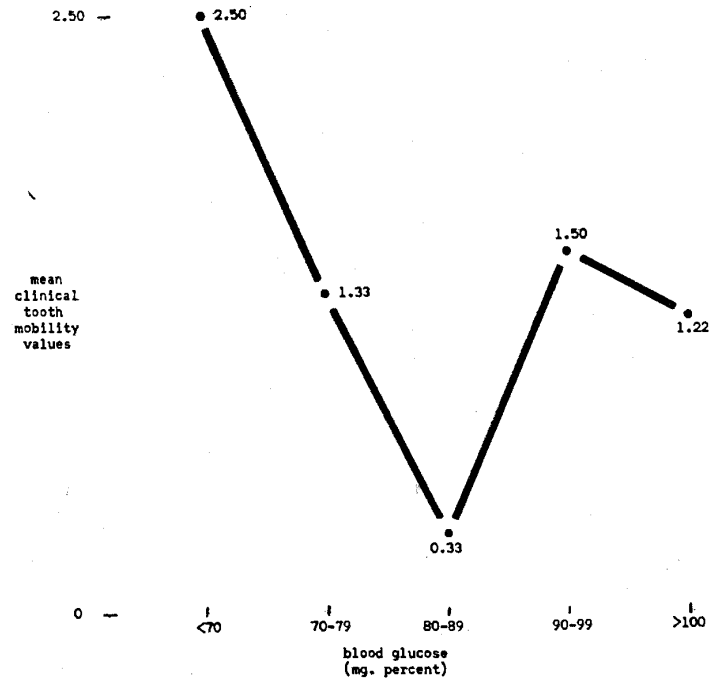

Fig. 4—Relationship of two-hour blood glucose to clinical tooth mobility (19 routine dental patients 40 to 49 years old).

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

range of two-hour blood glucose normality for a particular dental sign or combination of dental signs (Table 5) in the general range of 80-89 mg. per cent. These data also suggest that blood glucose levels above and below this narrow range are apt to be related to a higher incidence of the two oral signs.

It is interesting to compare the findings observed in this report with two-hour blood glucose levels with the observation already reported[1] with respect to fasting blood glucose levels and dental signs. In the main, the parabolic patterns shown with the fasting blood glucose levels were also observed with the two-hour determinations, although the patterns are not as clearcut at the two-hour interval.

Coefficients of Variation: Generally speaking, the lower the coefficient of variation, the more the individual scores cluster about the mean. Thus, a coefficient of variation of zero is the ultimate in that it signifies that all subjects provide scores exactly like the mean.

Table 6 summarizes the coefficients of variation with respect to the two-hour blood glucose and the single and combination analysis of oral signs. It is of interest to observe that there is a tendency for the coefficients of variation to be smaller at the higher blood glucose levels. Further, the coefficients of variation, in general, are smaller for the combination of the dental signs. This can be interpreted to mean that the individual scores more closely cluster about the mean in the case of hyperglycemia. Moreover, the smaller coefficients of variation at this extreme level are much more clearcut with respect to fasting blood glucose and oral sign analysis[1] than observed here in connection with two-hour blood glucose studies.

Probability Factors: Table 7 summarizes the P values for the various groups in terms of single and combination of dental signs with respect to two-hour blood glucose determinations. It is clear from this chart that there are no statistically significant mean differences.

Table 6—Comparison of Coefficients of Variation

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
clinical tooth mobility	138.57	125.08	126.40	115.50	74.17
tooth loss	155.00	116.24	128.38	72.23	93.28
clinical tooth mobility and tooth loss	140.44	117.31	88.73	77.35	72.96

Table 7—Comparison of Probability Values

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
clinical tooth mobility	.500	.500	>.200	>.400	
tooth loss	.500	.500	>.050	>.400	
clinical tooth mobility and tooth loss	.500	.500	>.050	.500	

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

Also, the tendency towards significance is greatest when comparing the 80-89 with 90-99 mg per cent groups in the analysis of tooth loss and the combination of the two dental signs. Further, when alternate groups are compared, as mentioned throughout this report, the statistical value of the differences becomes highly significant. Finally, a study of Table 7 and a similar one in an earlier report for fasting blood glucose[1] discloses a lesser tendency for statistical significance for the two-hour scores.

Age Factor: There are some investigators who contend that, with increasing age, the normal blood glucose values increase. Certainly the data from which this study is derived indicate that oral signs, in the main, occur predominantly in the older age groups.[7] Hence, it was thought necessary to analyze the relationship between oral signs and blood glucose levels in a single age group.

Figure 4 pictorially represents the relationship of two-hour blood glucose to clinical tooth mobility in the 19 patients between the ages of 40 and 49. An examination of Figure 4 demonstrates that the parabolic pattern which has been observed previously still prevails. No statistically significant differences were observed in this analysis (Table 8). However, a study of the <70 mg. per cent group versus the 80-89 mg. per cent group discloses a difference approaching statistical significance ($P > .050$).

Figure 5 is an analysis of the relationship of the two-hour blood glucose to tooth loss in the 19 patients between the ages of 40 and 49. An examination of Figure 5 and a comparison of these data and the findings in Figure 2 indicates that the parabolic pattern is greatly exaggerated when the age factor is eliminated, with the exception that the tooth loss values for the >100 mg. per cent blood glucose group is lower than

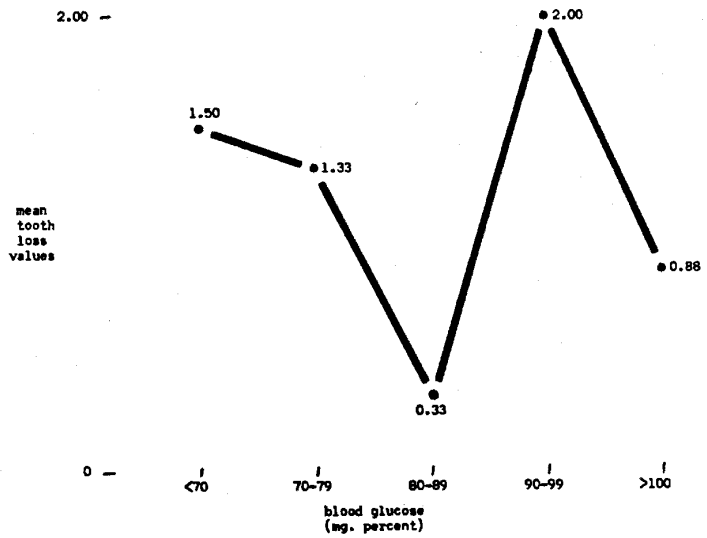

Fig. 5—Relationship of two-hour blood glucose to tooth loss (19 patients 50 to 59 years old).

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

for the preceding group. This is supported by the findings in Table 9. It can be observed that there are statistically significant values obtained when comparing the mean differences of the 80-89 versus 90-99 and 90-99 versus >100 mg. per cent blood glucose levels.

SUMMARY

1. This report analyzes the relationship of two dental signs (clinical tooth mobility and tooth loss) to the *two-hour* blood true glucose during glucose tolerance testing of a group of 100 routine dental patients.

2. An analysis of the mean score

Table 8—Relationship of Two-hour Blood Glucose to Clinical Tooth Mobility (40-49 year age group)

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
mean tooth mobility score	2.50	1.33	.33	1.50	1.22
standard deviation	.707	.578	.578	.707	1.093
coefficient of variation	28.28	43.46	175.15	47.13	89.59
mean difference	1.17	1.00	1.17	.28	
standard error of difference	.602	.472	.602	.618	
observed t value	1.9435	2.1186	1.9435	.4530	
degrees of freedom	3	4	3	9	
P	>.100	>.100	>.100	.500	

Table 9—Relationship of Two-hour Blood Glucose to Tooth Loss (19 patients between 40 and 49 years old)

	blood glucose groups (mg. per cent)				
	<70	70-79	80-89	90-99	>100
mean tooth loss score	1.50	1.33	.33	2.00	.88
standard deviation	2.121	1.155	.578	.000	1.054
coefficient of variation	141.40	86.84	175.15	0.00	119.77
mean difference	.17	1.00	1.67	1.12	
standard error of difference	1.976	.746	.335	.351	
observed t value	.0860	1.3404	4.9850	3.1908	
degrees of freedom	3	4	3	9	
P	.500	>.200	*<.010*	*<.025*	

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.

values for the two signs independently and in their combination points up the fact that the patterns are generally parabolic.

3. A study of the coefficients of variation for all of the blood glucose groups demonstrates that they are generally lower at the higher levels. However, this relationship is more clearcut with respect to *fasting* blood glucose analysis[1] than in the case of the *two-hour* blood glucose studies.

4. A study of the probability values indicates that the mean differences in most cases are insignificant. However, there is a tendency toward statistically significant differences when comparing the 80-89 mg. per cent blood group with the 90-99 mg. per cent group. Further, it appears that the probability values for the two-hour blood glucose comparisons with oral signs approach statistical significance less closely than previously observed with the fasting blood glucose patterns.

5. The findings suggest that the very same oral signs (clinical tooth mobility and tooth loss) are associated with both hyper- and hypoglycemia.

6. The evidence derived from this study suggests that the relationships analyzed are not associated significantly with the age factor.

7. These data suggest that the range of two-hour blood glucose normality may be more narrow than usually accepted.

8. A report to follow[14] will consider the relationship of tooth mobility and tooth loss to *three-hour* blood true glucose.

REFERENCES

1. Moller, P. and Cheraskin, E. *The relationship of fasting blood glucose to oral signs (dental findings).* Odontologisk Revy 11: #3, 255-270, 1960.
2. Rudy, A. and Cohen, M. M. *The oral aspects of diabetes mellitus.* New England Jour. Med. 219: #14, 503-508, October 6, 1938.
3. Rudy, A. and Cohen, M. M. *Oral aspects of diabetes mellitus.* J. A. D. A. 29: #4, 523-534, April 1942.
4. Kaplan, N. *Oral symptomatology of diabetes mellitus.* Penn. Dent. Jour. 41: #1, 50-51, 60-61, November 1938.
5. Rutledge, C. E. *Oral and roentgenographic aspects of the teeth and jaws of juvenile diabetics.* J. A. D. A. 27: #11, 1740-1750, November 1940.
6. Martinez, E. *Diabetes in dental practice.* Dent. Abst. 1: #3, 178, March 1956.
7. Sheridan, R. C., Jr., Cheraskin, E., Flynn, F. H. and Hutto, A. C. *Epidemiology of diabetes mellitus: II. A study of 100 dental patients.* Jour. Periodont. 30: #4, 298-323, October 1959.
8. Cheraskin, E. and Moller, P. *The normal glucose tolerance pattern: The development of blood glucose normality by an analysis of oral signs (dental findings).* Jour. West. Soc. Periodont. 8: #3, 81-94, September 1960.
9. Lovestedt, S. A. and Austin, L. I. *Periodontoclasia in diabetes mellitus.* J. A. D. A. 30: #3, 273-275, February 1943.
10. Barach, J. H. *Diabetes and its treatment.* 1949. New York, Oxford University Press. p. 54.
11. Somogyi, M. *A new reagent for the determination of sugars.* Jour. Biol. Chem. 160: #1, 61-68, September 1945.
12. Somogyi, M. *Determination of blood sugar.* Jour. Biol. Chem. 160: #1, 69-73, September 1945.
13. Nelson, N. *A photometric adaptation of the Somogyi method for the determination of blood sugar.* Jour. Biol. Chem. 153: #2, 375-380, May 1944.
14. Moller, P. and Cheraskin, E. *The relationship of three-hour blood glucose to oral signs (dental findings).* (in preparation).

Press of Charles C. Morchand Co., N. Y. C.

Copyright © Price-Pottenger Nutrition Foundation. All rights reserved.
No part of this research may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Visit http://ppnf.org for more information.