

# A comparison of gingival crevice pH of dental students and patients with gingivitis

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## SUMMARY

*Eight dental students (designated Group A) and 8 patients with clinical gingivitis (group B) were the subject of this experiment. The average gingival index in Group A was less than one and in Group B it was greater than two. Using an antimony micro-electrode measurements of supragingival plaque pH and gingival crevicular pH were made. These readings were analysed by comparing their means directly, and by comparison with gingival indices and crevicular depths. The results obtained indicated no significant variations between the 2 groups. Within the groups there were significant differences in crevice pH according to pocket depth and degree of inflammation. There was a general decrease in pH with increasing pocket depth. Group B showed a gradient of pH increasing with increasing inflammation.*

## OPSOMMING

*Agt tandheekkunde-studente (groep A) en 8 pasiente, elk met kliniese gingivitis (groep B), is in hierdie eksperiment gebruik. Die gemiddelde gingivale indeks vir Group A was minder as een en vir Groep B meer as twee. Met gebruikmaking van 'n antimoon-mikro-elektrode is opnames van die supragingivale plaak pH en gingivale sulkus pH gemaak. Hierdie lesings is ontleed deur 'n direkte vergelyking met die gemiddeldes en met beide die gingivale indekse en gleufdieptes te maak. Die ondersoek het getoon dat daar geen noemenswaardige verskille tussen die twee groepe bestaan nie. 'n Betekenisvolle verskil in sulkus pH het wel onder groepe bestaan sover dit sak-diepte en graad van ontsteking betref. In die reel het 'n vermindering in pH met 'n verdieping van sak-diepte saamgegaan. Groep B het 'n verhouding van vermeerderde pH met verhoogde inflammasie getoon.*

## INTRODUCTION

Although much work has been done on the pH of plaque, there are few reports in the literature regarding gingival crevice pH. Still less information is available on the differences in pH of crevices in clinically normal and inflamed gingivae. Several investigators have compared crevicular pH to periodontal pocket depths.

Studies which have been carried out on normal gingivae include the following: Box (1940) used a colorimetric procedure to evaluate crevice pH and found that it ranged from 7,3 to 7,5. Kleinberg and Hall (1969) used an antimony microelectrode in an analysis of crevicular pH in various parts of the mouths of undergraduate dental students, and found an average of 8,34. This was 0,64 higher than the corresponding supragingival plaque pH determined in a previous investigation (Kleinberg and Jenkins, 1964).

Comparisons of periodontal pocket depths and crevicular fluid pH have been carried out by Gilbert (1951), Forscher, Paulsen and Hess (1954), and Kleinberg and Hall (1969). Gilbert (1951), using a quinhydrone electrode, found that the pH in pockets, ranging in depth from 2 mm to 10 mm, increased with increasing pocket depth. Forsher, Paulsen and Hess (1954) observed a similar trend. Statistical analysis of their results, however, showed that the differences obtained were not statistically significant. Kleinberg and Hall (1969) found that pH of crevices increased up to an approximate depth of 0,7 mm and then decreased with increasing depth for crevices up to 3 mm.

Comparisons of crevicular pH and degree of inflammation of the gingivae have been carried out by Paulsen (1950) and Smith, Rule and Rosen (1974). Paulsen (1950) used a quinhydrone electrode and found that normal crevices had a mean pH of 6,9; acutely inflamed gingivae had a slightly lower pH and those classified as chronically inflamed had a slightly higher pH. Smith *et al* (1974) compared gingival index, crevice depth, supragingival plaque pH, crevicular fluid pH and collagenase activity among 25 children ranging in ages from 9 to 15 years. They found the average gingival index in their sample to be 1,03 in males and 1,26 in females; average crevice depth 2,30 mm in males and 2,05 mm in females and average crevice pH 7,93 in males and 7,25 in females. These authors also used an antimony microelectrode for determining pH.

The present study was undertaken to determine whether a significant difference in crevice pH existed between clinically normal and inflamed gingivae. In addition, measurements were made of supragingival plaque pH, crevice depth and the pH of resting saliva.

## METHODS AND MATERIALS

The subjects in this study were divided into two groups. Groups A consisted of second year dental students, while Group B consisted of selected outpatients attending the School of Dentistry of the University of the Witwatersrand. The patients in the latter group all displayed clinical gingivitis. Most of these patients also had chronic periodontitis as evidenced by recession of the gingivae and mobility of teeth.

The antimony microelectrode as described by Kleinberg (1958) and modified by Norman, Swartz and Phillips (1966) was utilised for pH measurements. The electrode was connected to an Orion Research Digital pH Meter (Model 701)<sup>1</sup> (Fig. 1) utilizing its relative millivolt scale for crevice and supragingival pH recordings. The corresponding pH was read off from a calibration curve which was determined for each electrode. A number of antimony microelectrodes were assessed before commencement of the experiment. Those which gave irregular readings when placed in standard buffer solutions of known pH, were discarded. The calibration curve was constructed by determining the millivolt readings obtained from buffer solutions ranging in pH from 3 to 9. The pH values of the buffer solutions were recorded with a Beckman Zeromatic II pH Meter<sup>2</sup> fitted with a glass electrode. A straight line graph should result by plotting millivolt readings against pH. The antimony microelectrodes are extremely brittle and should be handled carefully. Whenever an electrode broke, another electrode was calibrated and new readings recorded for the particular patient.

The reference electrode in the system was a calomel electrode connected to the antimony electrode via a KCl salt bridge (Fig. 1). The holder containing the saturated potassium chloride was a modification introduced by Retief (1974) of the original design by Norman *et al* (1966). A thin polyethylene tube was connected to the container and delivered a continuous small amount of KCl to the oral cavity to provide the connecting link between the two electrodes (Fig. 2).

The pH of the mixed resting saliva of each patient was recorded prior to determining the other pH values. In order to minimise the subsequent effect of saliva on the crevicular and supragingival pH, cotton wool rolls were placed in the buccal sulci and readings were first recorded on the teeth in the lower jaw.

Crevice depth readings were taken using a graduated periodontal probe and the gingival index recorded at the same time according to the criteria of Loe (1967). This simultaneous recording was possible as the index relies mainly on the presence or absence of bleeding on light probing.

In view of the lack of control over the patients in group B, no instructions on oral hygiene procedures were given prior to examination. This was in contrast with the experimental procedures adopted by Kleinberg and Hall (1969) whose subjects were instructed to cease oral hygiene procedures for a period of 3 days prior to examination. In addition, their subjects were starved 12 hours prior to examination. The reason for this was that the authors wished to compare their results with those previously reported (Kleinberg and Jenkins, 1964). Smith *et al* (1974) instructed their subjects not to brush or eat 12 hours prior to examination.

Readings were recorded on the buccal and lingual surfaces of the following teeth 11, 14, 23, 31, 34 and 43. These teeth were selected because of accessibility and because they were thought to be more likely to be

present in the patients in group B. When these teeth were missing either the adjacent tooth or the contralateral tooth was used.

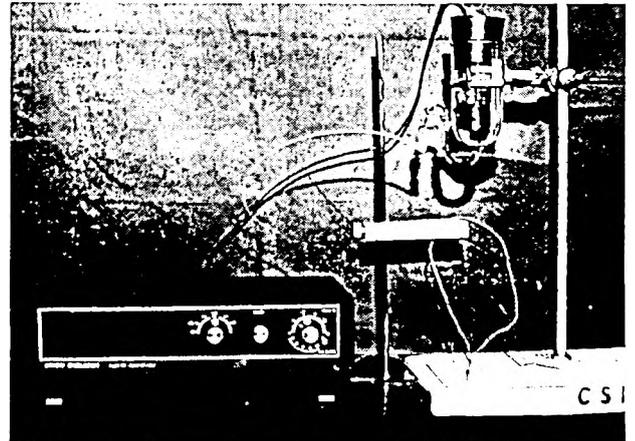


Fig. 1. The Orion Research (Model 701) Digital pH Meter connected to the antimony electrode via a saturated KCl salt bridge.



Fig. 2. The antimony electrode and KCl salt bridge in position in the mouth.

## RESULTS

The results obtained in this study are summarized in Table 1. The pH recorded for the resting saliva, the supragingival plaque and the crevices were lower in Group B than in Group A. Analysis of the results by the Student's *t* test showed that these differences were not significant.

The gingival indices of patients in Group A ranged from 0 to 0,7 with a mean of 0,34 and in Group B from 1,6 to 2,4 with a mean of 2,03. The mean crevice depth in Group A was 1,41 mm and in Group B 3,08 mm. Since the gingival indices and crevice depths in the two groups were unequally distributed, a standard deviation of the means of these recordings was not determined and a Median test had to be applied to evaluate the results statistically. The differences between the gingival indices found in the two groups were significant at the 1% level but no significant difference was observed between the mean crevice depths.

<sup>1</sup>Orion Research Incorporated, 11 Blackstone Street, Cambridge, Mass. 02139, U.S.A.

<sup>2</sup>Beckman, Instruments, Inc., Fullerton, Calif. 92634, U.S.A.

TABLE I  
SUMMARY OF RESULTS OBTAINED

	Group A	Group B	Significance Level
Number of Patients	8	8	
Mean Saliva pH $\pm$ S.D.	6,49 $\pm$ 0,48	6,04 $\pm$ 0,55	<sup>1</sup> Not significant
Number of Recordings	96	96	
Mean Supragingival Plaque pH $\pm$ S.D.	6,43 $\pm$ 0,42	6,16 $\pm$ 0,37	<sup>1</sup> Not significant
Mean Crevicular pH $\pm$ S.D.	7,11 $\pm$ 0,33	6,75 $\pm$ 0,50	<sup>1</sup> Not significant
Mean Gingival Index	0,34	2,03	<sup>2</sup> 1%
Mean Crevicular Depth (mm)	1,41	3,08	<sup>2</sup> Not significant

<sup>1</sup>Student's t test

<sup>2</sup>Median test

The mean crevicular pH and mean supragingival plaque pH recorded in the two groups are presented in Table II. The mean crevicular pH in both groups was significantly higher than the mean supragingival plaque pH. The differences in both cases were significant at the 0,5% level. These findings were in keeping with the observations of Kleinberg and Hall (1969) who found that the gingival crevice pH was approximately 0,6 higher than the pH of the supragingival plaque. Evaluation of the supragingival plaque pH is open to criticism because it was not possible to control the experimental conditions in the patients obtained from the clinical departments prior to pH measurements. For this reason the dental students were also not instructed regarding oral hygiene and food intake.

The results obtained for the buccal and lingual crevicular pH in the two groups are tabulated in Table III. The differences between the mean buccal crevicular pH and the mean lingual crevicular pH within each group were not significant. In addition, the results obtained for the buccal crevicular pH and the lingual crevicular pH were evaluated statistically between the two groups and also found to be not significant. Kleinberg and Hall (1969) in their study found that the lingual crevicular pH was significantly higher than the buccal crevicular pH ( $P < ,001$ ).

The crevicular pH was related to the gingival index (Table IV). The difference between crevicular pH corresponding to gingival indices of 0 and 1 was not statistically significant. Since only two pH recordings were done in patients with a gingival index of 2 in Group A, these results were not subjected to statistical analysis. The slight differences obtained in the mean

TABLE II  
COMPARISON (WITHIN GROUP) OF  
CREVICULAR pH AND  
SUPRAGINGIVAL PLAQUE pH

	Mean Crevice pH $\pm$ S.D.	Mean Supra- gingival Plaque pH $\pm$ S.D.	Significance Level
Group A	7,11 $\pm$ 0,33	6,43 $\pm$ 0,42	0,5%
Group B	6,75 $\pm$ 0,5	6,16 $\pm$ 0,37	0,5%

crevicular pH of patients with gingival indices of 0 and 1 respectively may result from the difficulty in distinguishing clinically between these two indices. An objective classification of these closely related indices was practically impossible. In Group B, however, a progressive increase in mean crevicular pH was obtained when related to the gingival indices. Using the analysis of variance to find the F ratio, these results proved to be significant at the 1% level.

In Table V the crevicular pH was related to crevice depth. Interpretation of these results proved to be more difficult. By subjecting the results to an analysis of variance, it was found that the differences in mean crevicular pH when related to crevice depth were significant at the 1% level. The general trend was a decrease of crevicular pH with increasing crevice depth.

TABLE III  
COMPARISON OF BUCCAL AND  
LINGUAL CREVICULAR pH

	Group A	Group B	Significance Level (t test)
Number of Recordings	48	48	
Mean Buccal Crevicular pH $\pm$ S.D.	7,05 $\pm$ 0,41	6,67 $\pm$ 0,50	Not significant
Mean Lingual Crevicular pH $\pm$ S.D.	7,18 $\pm$ 0,36	6,83 $\pm$ 0,53	Not significant
Significance Level (Student's t test)	Not significant	Not significant	

TABLE IV  
CREVICULAR pH IN  
RELATION TO GINGIVAL INDEX

	Group A			Group B		
Gingival Index	0	1	2	1	2	3
Number of Recordings	64	30	2	17	60	19
Mean Crevicular pH $\pm$ S.D.	7,16 $\pm$ 0,64	7,05 $\pm$ 0,59	6,98 $\pm$ 0,11	6,29 $\pm$ 0,53	6,67 $\pm$ 0,68	7,11 $\pm$ 0,62
Significance Level	Not Significant (Student's t test)			1% (Analysis of variance)		

TABLE V  
CREVICULAR pH TABULATED  
IN RELATION TO  
CREVICULAR DEPTH

	Group A			Group B			
Crevicular Depth (mm)	1	1,5	2	2	2,5-3,0	3,5-5,0	5,5-8,0
Number of Recordings	59	4	32	41	34	13	8
Mean Crevicular pH $\pm$ S.D.	7,29 $\pm$ 0,64	6,72 $\pm$ 0,48	6,82 $\pm$ 0,48	6,50 $\pm$ 0,71	7,13 $\pm$ 0,56	6,76 $\pm$ 0,71	6,54 $\pm$ 0,31
Significance Level (Analysis of variance)	1%			1%			

## DISCUSSION

Analysis of the results obtained in this study showed that the two groups of subjects examined did not vary significantly as regards their crevicular pH. This would seem to indicate that crevicular pH among subjects with inflamed gingivae is not significantly different from that found in normal mouths.

Analysis of crevicular pH compared to gingival index and crevice depth within the groups, revealed contradictory results. Table IV indicated increasing gingival crevicular pH with increasing gingival index in Group B. Table V revealed a reverse trend, namely, the crevicular pH were decreased with increasing pocket depth. This was surprising, as both gingivitis and periodontal disease are pathological processes which are interrelated. The possible association between crevicular and plaque pH and degree of inflammation and pocket depth is not straight forward as there are many factors that determine crevice and plaque pH.

Kleinberg (1970) discussed these factors at length. According to him, factors which would tend to lower the crevicular pH were: carbohydrate metabolism, amino acid catabolism, oxygen depletion (through lactic acid accumulation) and the presence or absence of inflammatory exudate (Menkin, 1956). On the other hand, the following factors tended to raise the crevicular and plaque pH: nitrogenous substrates especially urea, an increase in salivary flow, fluorides and an as yet unidentified "salivary pH — rise factor". Of these latter factors, urea was regarded as the most important. Its catabolism results in the release of ammonia which tends to raise the pH. Saliva has a high concentration of urea. Since deeper pockets are

less accessible to saliva, one would expect their pH to be lower (Kleinberg and Hall, 1969). This was observed in this investigation.

Kleinberg and Hall (1969) further postulated that crevice organisms had greater access to debris and fluid in the crevices than the organisms in plaque, while plaque flora had greater access to dietary substrates. End-products of metabolism within the crevice are also removed with greater difficulty than those of plaque. These factors all contribute to the higher pH found in crevices compared to plaque. The more basic environment of the gingival crevice tended to favour calculus formation, while caries in the crevicular regions was relatively uncommon.

The finding in the present investigation that the crevice pH increased with increasing degree of inflammation in Group B is inconsistent with the postulate that inflamed tissue has a lower pH than normal tissue.

As the number of subjects examined in this investigation was relatively small, further research using larger samples is indicated in order to confirm or reject the present findings.

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