The relationship between pH and buffering capacity of whole saliva to dental caries in children

Abbas Naqvi, BDS MDSc, Martin E.J. Curzon, PhD, LDSRCS

ABSTRACT
Objectives: To develop a test to screen children for caries susceptibility and/or prediction by establishing various correlations between pH and buffering capacity of whole saliva in three groups of children. Subjects: Appropriate written informed consent was taken. Children were divided into three groups depending on whether they had active caries, treated caries or no caries at all. Design: A population of children was divided into three groups depending on their current caries status. Whole saliva was collected and pH and buffering capacities were measured. Results: A strong correlation between pH and buffering capacity could not be established. Conclusions: Although these factors come into play during cariogenesis, they do not present as an accurate, reliable and reproducible method of monitoring caries activity due to the dynamic and highly variable oral condition at any given time. The concurrent lack of sensitivity preclude these tests for individual caries susceptibility testing.

Keywords: Saliva, buffering capacity, pH, saliva tests.

The chemico-parasitic theory of tooth decay advanced by Miller in 1890 is still widely accepted. This theory supports the proposition that acid produced by bacteria act to dissolve tooth structure. Since then several workers have demonstrated the production of oral acids at tooth decay sites. Bibby et al. were able to demonstrate tooth decalcification by acid production by oral bacteria. In 1944 Stephan illustrated a sharp drop in salivary pH following a glucose rinse. Hanke attempted to correlate the local acidity of different areas of the mouth with caries, but found no pH value lower than 5.4. In light of the works of Hanke and Stephan, interest was shown in salivary pH and salivary buffering effect to acidic changes in relation to caries. This led to the question as to whether the buffering capacity of saliva could affect caries onset or its progression. Several other related studies have been carried out in this area with no conclusive result.

The aim of this study was to establish whether there is:

1. a difference between the mean pH and buffering capacity of saliva in children with different caries experiences;
2. a correlation between salivary pH and buffering capacity in children; and
3. a test which could be established to diagnose imminent caries, monitor existing caries activity or progression of an established lesion in children.

Material and methods The subjects were 12 and 13 years of age. Appropriate informed consent was taken from the parents of the children. The subject population was divided into three groups based on the caries status of individual subjects. Caries free (Cr) subjects were those who had no caries experience while those who had received at least four restorations as a result of caries and had no further signs of the disease were termed caries restored (Cr). The caries active (Ca) group was defined as those that had at least four active and untreated carious lesions. Caries diagnostic criteria were those used by Radke. No deciduous teeth or children in the mixed dentition were included in the present study. Children who had orthodontic bands or appliances were not included in the study population. Whole stimulated saliva was collected on two separate visits at an interval of three months. Saliva was collected between 09:00 am and 11:00 am to avoid changes due to circadian rhythms. This also ensured that the subjects had not eaten or brushed their teeth in the preceding hour. Salivary pH was measured immediately at the time of collection to avoid changes in its pH by the degeneration of the bicarbonate ion. pH was measured using a hydrogen ion sensitive dip stick paper called Spezialindikator (Spezialindikator, E. Merck, Darmstadt, F.R. Germany). Salivary buffering capacity was measured using a commercially available kit called Dentobuff (Dentobuff, Orion Diagnostica, Espoo, Finland). The method for salivary collection and estimation of its buffering capacity was in concordance

From the Dental Department, Al-Ain Hospital, UAE (Naqvi), and Department of Child Dental Health, University of Leeds, UK (Curzon).

Received March 1996. Accepted for publication in final form June 1996.

Address correspondence and reprint request to: Dr. Abbas Naqvi, Dental Department, Al-Ain Hospital, PO Box 1006, Al-Ain, UAE. Fax No. 971-3-634073.
with the manufacturers recommendation.

**Results** The subject population consisted of forty seven children who were examined twice. There were 34 girls and 13 boys in the study population. There was no significant age difference (p<0.01) between the boys and the girls. The subject population was segregated by the sexes and the data for both examination visits were pooled. The averages for pH and buffering capacity of saliva were computed and are given in the table shown below. There were no differences in pH and buffering capacity in the two respective examinations when the Student’s t-test was applied at 99% level of confidence (p<0.01). There were no differences between the sex samples with regard to their pH and buffering capacity.

<table>
<thead>
<tr>
<th>Table 1 - pH and buffering capacity values in the population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examination visit 1</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Avg pH population</strong></td>
</tr>
<tr>
<td><strong>Avg pH females</strong></td>
</tr>
<tr>
<td><strong>Avg pH males</strong></td>
</tr>
<tr>
<td><strong>Avg buffering capacity population</strong></td>
</tr>
<tr>
<td><strong>Avg buffering capacity females</strong></td>
</tr>
<tr>
<td><strong>Avg buffering capacity males</strong></td>
</tr>
</tbody>
</table>

in both intra and inter-examination visits. Data for both the examination visits were pooled (Table 2). The three samples (Cf, Cr and Ca) in the population did not have significantly different pH or buffering capacity values. The average pH and buffering capacity for each subject over both examination visits was calculated and plotted as shown in the chart below. Saliva in the subject population showed a buffering capacity towards the acidic range while the pH remained relatively constant in all three caries status groups. Correlation analysis was carried out using pH and buffering capacity values to test if a relationship existed between the two parameters. There was a poor correlation (r = 0.4). The standard error was calculated and found to be insignificant at p < 0.01. This suggested that the buffering capacity and pH are independent of one another even though other studies suggest that they are related.

**Discussion** The subject population was initially larger. There was a drop out from the study as some children could not be examined at the appointed time. Some children were not well at the time of saliva collection and some had been chewing gum or eating chips prior to saliva collection. Subjects were all within the same age group. Various workers have shown changes in salivary pH with age. However, Andersson et al. did not find a significant difference between the age groups they studied. This study could not establish a correlation between caries status and pH and buffering capacity of saliva (Tables 1 and 2). This is in concordance with some workers. Other workers have all found a negative correlation between pH buffering capacity and caries. Lambert et al. showed that the pH of saliva falls initially then slowly rises. The lack of agreement in the field about the relationship of pH and buffering capacity of saliva to dental caries could be due to several other factors coming into play at the time of saliva sampling or at the time of active acid demineralization. Caries is multifactorial and during acid demineralization, several of these factors come into play concurrently. Such factors as the plaque pH at the tooth/plaque interface, the observation that in some children there is production of alkaline peptides following a carbohydrate challenge and possibly, a difference in saliva sampling technique could all affect the pH and buffering capacity. From in vitro experiments, Theuns et al. have shown that demineralization is related to pH and in fact, the lower the pH the faster the rate of demineralization of enamel. Other factors such as oral clearance, bacterial composition and activity come into play when caries activity is considered. These are all beyond the scope of the present paper but could explain the difference between workers when considering pH and buffering effect of saliva. The hypothesis that there is a correlation between salivary pH and buffering capacity was tested. The results obtained from the present study show that there is no such correlation. They are separate entities although they may be related. Similar results have been obtained elsewhere. Other studies have not studied the relationship between pH and buffering effect per se. This again supports the fact that the multifactorial cause of caries presents a single test being reliably used in the prediction, or even monitoring of caries. Salivary buffering capacity and pH of saliva at tooth-plaque interface in itself are two of several factors which come into play during cariesogenesis. The lack of agreement between caries indices and the pH and buffering effect of saliva preclude the use of saliva tests alone in the diagnosis of caries development in the individual child. This weakness of the test as a prophylactic instrument does not, however, exclude the use of the test in investigations of children with high caries activity. These tests

<table>
<thead>
<tr>
<th>Table 2 - Average pH and buffering capacity values in the three groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>No of subjects</td>
</tr>
<tr>
<td>Avg pH</td>
</tr>
<tr>
<td>Avg buffering capacity</td>
</tr>
</tbody>
</table>
although lacking in sensitivity provide information regarding the general status of the salivary hydrogen ion management in the oral cavity. Research into the buffering capacity of saliva and various pH changes occurring at the enamel/plaque interface have to be studied as this is where caries begins. It is necessary to standardize sampling techniques as saliva is in itself the very antithesis of a pure substance and previous studies have sampled various presentations of saliva. The highly dynamic status of caries activity also creates problems in assessing caries activity which had already taken place in a given individual. There is a necessity to monitor salivary pH and its buffering capacity at the point of enamel de-mineralization over a long period of time (24 hours) probably using telemetric techniques. Enamel decay can be encouraged and changes measured or observed.

References