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Original Research

Evaluation of effects of commonly used carbonated beverages and commercially available tooth pastes on enamel: An *in vitro* study

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ABSTRACT

Tooth wear or the loss of the tooth surface is considered to be the next most significant threat to the human dentition, after trauma, dental caries and periodontal diseases. High risk of enamel erosion is noted in various parts of India due to consumption of carbonated beverages amongst various age groups. Loss of enamel due to usage of dental abrasives present in the commercially has been a major of concern over the past decade. Although REA and RDA levels are tested before the public usage, some amount of enamel loss occurs over the long run.

This study investigates the possible loss of enamel due to consumption of popular carbonated beverages and commercially available toothpastes and their synergistic effects.

Introduction

Tooth wear is the term used to describe the progressive loss of a tooth' s surface due to actions other than those which cause tooth decay or dental trauma. It is considered to be the next most significant threat to the function and longevity of human dentition, after trauma, dental caries and periodontal diseases. Tooth wear may occur due to- erosion, abrasion, attrition or abfraction.

Dental erosion is defined as tooth wear due to dissolution of dental hard tissues by acids without the involvement of bacteria.[1] With over half of 15-18 year olds exhibiting incisal erosion, it is being seen more commonly and frequently in adults and children. [2]

Recent studies show that there is a high risk of enamel erosion due to carbonated beverages among the teenagers in parts of India.[3] Several factors such as, chemical properties of the erosive medium and the frequency and the method of contact between acid and tooth lead to erosion. Also, factors such as effectiveness of the protective mechanisms in the oral cavity, which includes salivary composition, flow rate, buffering capacity, pellicle formation, clearance rates and individual dental anatomy results in erosion of teeth. [4] Consumption of carbonated beverages leading to dental erosion is a growing problem. Irreversible loss of enamel from tooth surface is resulted with exposure to an erosive medium and a layer of softened enamel 0.5-5 μm thick may be worn out. [5,6]

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Dental abrasion is the wearing away of the hard tissues of oral cavity through physical means other than teeth. Tooth pastes, which typically contain abrasives and detergents, are used as cleansing and discolouration removal agent.[7,8] It is widely accepted that tooth pastes require some amount of abrasivity to remove or reduce stains. Since, softened surface is more susceptible to abrasion, brushing the teeth immediately after consumption of carbonated beverages accelerates enamel loss. [9,10] The softened tooth enamel is worn out if the time for remineralisation of enamel is insufficient and abrasion occurs immediately after erosion. [9,10]

Attrition is loss of tooth substance caused by physical tooth-to-tooth contact, such as may occur in bruxism. A degree of attrition is normal, especially in elderly individuals.[17] While, abfraction is loss of cervical tooth substance purportedly caused by flexure of teeth under occlusal loading.[18]

Tooth wear is common from early age, suggests epidemiological data. [11,12] Though erosion may be a dominant factor in a majority of surveys considering tooth wear, multi-factorial etiology of the condition would suggest that wear scores are a result of interaction between various physical and chemical agents. [13] Thus, hard tissue loss from the surface of the teeth are a synergistic effect of surface attrition, abfraction, erosion and abrasion. [14]

Soft drink or non-alcoholic beverages are one of the major reasons causing erosion. [13] While, for abrasion, the focus is on toothpastes, since certain degree of abrasivity is needed for efficient cleaning and stain removal. [15] It has been noted enamel, though is resistant to significant abrasion by most toothpastes, and is highly sensitive to erosion by acid substances. Radiotracer methods are used to put limit on degree of abrasivity by international and national standards on the toothpastes. Relative Dentine Abrasivity (RDA) and Relative Enamel Abrasivity (REA) levels are tested before releasing a toothpaste for public usage. [16]However, it is interesting to know the synergistic effect of abrasion by toothpastes after erosion by beverages on the total amount of tooth wear.

This study aims to evaluate the erosive effects of some of the commonly used carbonated beverages, the abrasive effects commercially available toothpastes and their additive effect. It will be interesting to see the amount of tooth wear caused by the beverages and toothpastes present in the present day Indian markets.

Profilometer is ideal to measure the surface roughness of the tooth. Unlike hardness testers, these systems do not damage the surface of the tooth while measuring and also account for good precision and accuracy.

The abrasion effects of various toothpastes must be evaluated under similar conditions to produce effective and accurate comparison. Hence, a machine with a definite load and frequency is necessary to abrade the all the selected samples.

Such a study is the need of the hour keeping in mind the increasing consumption of beverages and the number of toothpaste brands available in the society. A better knowledge of their effects will help in preventing the adverse effects of tooth wear like dental sensitivity, caries, gross destruction of tooth and also, poor aesthetics.

MATERIAL AND METHODOLOGY

Beverages and toothpaste:

Four commercially available beverages (B1, B2, B3 and B4) were selected based on their sales and popularity and their pH was determined using a pH meter, samples with least pH were selected for the

study. Four toothpastes (T1, T2, T3 and T4) were chosen of which two were multinational brands while the other two were Indian herbal toothpastes.

Figure 1: Extracted teeth embedded in acrylic blocks

Figure 2: Acrylic block

This study was a single blind study and the operator was not aware of the identity of the brands.

Sample Preparation:

One hundred and fifty previously extracted teeth samples were first collected and then cut from the sides with the help of water cooled diamond saw. These samples were then placed in polyurethane moulds and embedded into epoxy resin for a day. Samples were then ground and polished using a polishing unit. A baseline measurement of each sample would be taken using Profilometer. The samples were randomly allocated to four sub groups of fifteen samples each for each of group A and B. A separate group with fifteen samples would be used as control.

Profilometric analysis:

A profilometer is a device used to measure the surface roughness of the given sample. The profilometer gives a tracing of the sample using digital and analog

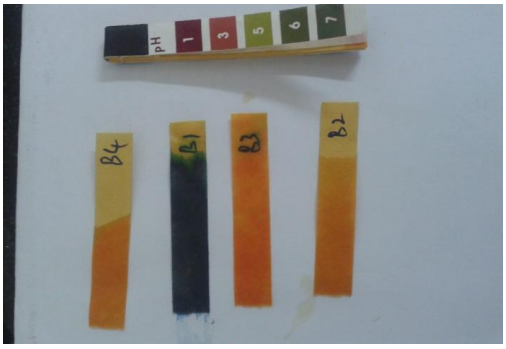

Figure 3: pH strips indicating the pH of sample beverages

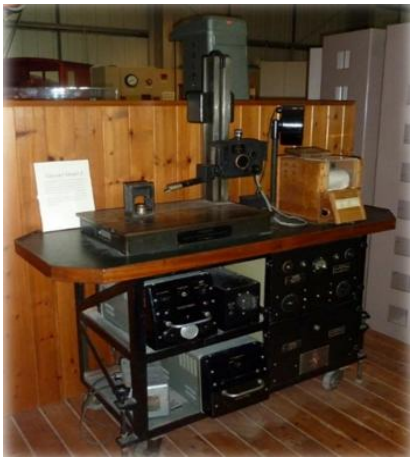

Figure 4: Profilometer

Figure 5: Customized Brushing Machine

hardware and software. It calculates the average surface roughness (RA) value for the resultant

tracing.[25] The surface roughness was measured using the profilometer (Taylor Hobson Precision SURTRONIC 3+) for each specimen and values were recorded before and after the experimentation.

Group A: Erosion Subgroups (B1, B2, B3, B4 and B5)

Fifteen teeth samples in each subgroup were simultaneously exposed to 500ml of selected beverage with continuous stirring for uniform contact of all surfaces. The samples were then removed after 20 minutes and rinsed with distilled water. These specimens were exposed to air for drying.

This process was repeated with beverage B1, B2, B3 and B4 for 15 days. A separate group of fifteen samples was used as control in sub group B5 and was immersed in synthetic saliva (Potassium: 20 meq/lit, Chloride: 27.4 meq/lit, Sodium: 0.22 mg, Magnesium: 1.5 mg, Calcium: 0.6 mg, Fluoride: 0.5 mg, Phosphorous: 0.21 mg, Hydroxy propyl methyl cellulose 3%).

Group B: Abrasion Subgroups (T1, T2, T3, T4 and T5)

Customized brushing model

A custom made brushing apparatus was constructed by the expert consultation. The brushing apparatus was designed to deliver uniform force and uniform unidirectional motion to the tooth surface.

The customized brushing apparatus consists of the following parts:

- Motor: To deliver a uniform force and move toothbrush in back and forth direction.
- Handle: To which toothbrush can be attached.
- Base: To support the whole apparatus.

Fifteen teeth samples in each subgroup were brushed with the toothpaste slurry using the customized brushing machine. Both the facial and the occlusal surfaces were subjected to brushing. The samples were brushed for 2 minutes twice a day for 15 days.

This process was repeated with toothpastes T1, T2, T3 and T4. A separate group of fifteen samples was used as control T5 and was brushed using water. The brushing was done with soft bristle brushes and brush heads were changed for each subgroup.

Group C: Synergistic Effects

From the above two groups, the most erosive beverage from Group A and the most abrasive toothpaste from Group B were identified. The samples which were eroded the most were brushed with the most abrasive paste for 2 minutes twice a day for 15 days with the customized brushing machine. Also, the control samples in both the groups were taken and subjected to brushing after the erosion by synthetic saliva.

After performing the experiment, the samples were washed with distilled water and dried in the air. The samples were then measured using the profilometer and the difference between the present measurement and baseline measurement were noted. The difference is the amount of teeth wear that has occurred.

Statistical Analysis:

The data was collected and was analysed with consultation of a statistician. ANOVA test was applied to analyse intra-group data and Scheff' s test was applied for inter-group analysis. The findings were then studied to draw appropriate inferences and conclusions.

RESULTS:

The selected beverages were tested with the pH meter and readings ranged as follows:

Beverage	pH Values
B1 Control Group	6.2-7.4

B2	2.5-3.2
B3	2.5-3.5
B4	3.4-4.6
B5	2.8-3.7

Groups	*Count*	*Sum*	*Average (in mm)*	*Variance*
B1	15	0.1203	0.00802	6.13E-05
B2	15	8.675	0.578333	0.019422
B3	15	1.99	0.132667	0.000931
B4	15	0.881	0.058733	0.001237
B5	15	0.824	0.054933	0.005026

Table 2

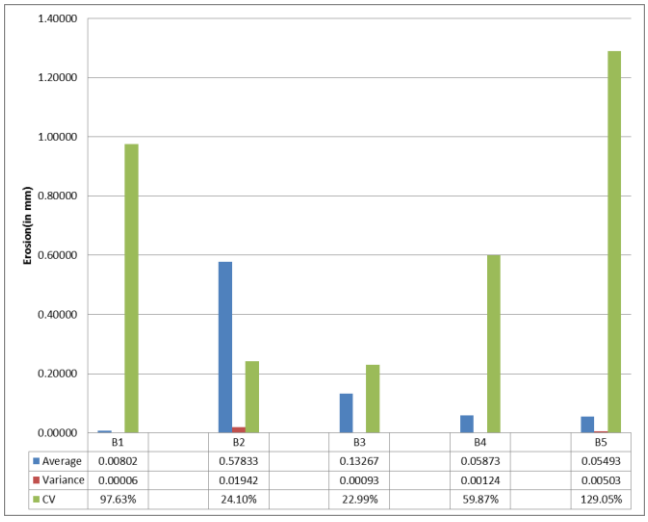

Figure 6

Group B Results:

Groups	*Count*	*Sum*	*Average (in mm)*	*Variance*
T1	15	2.535	0.169	0.001123
T2	15	10.216	0.681067	0.03242
T3	15	3.088	0.205867	0.006778
T4	15	6.304	0.420267	0.00606
T5	15	0.1576	0.010507	5.08E-06

Table 3

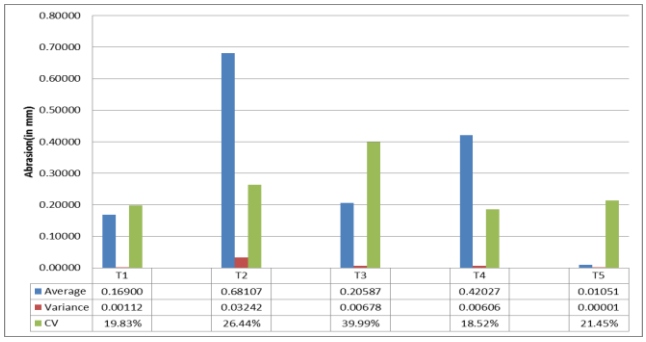

Figure 7

Group C Results:

Groups	*Count*	*Sum*	*Average (in mm)*	*Variance*
S1	15	12.551	0.836733	0.028433
S2	15	32.903	2.193533	0.053144

Table 4

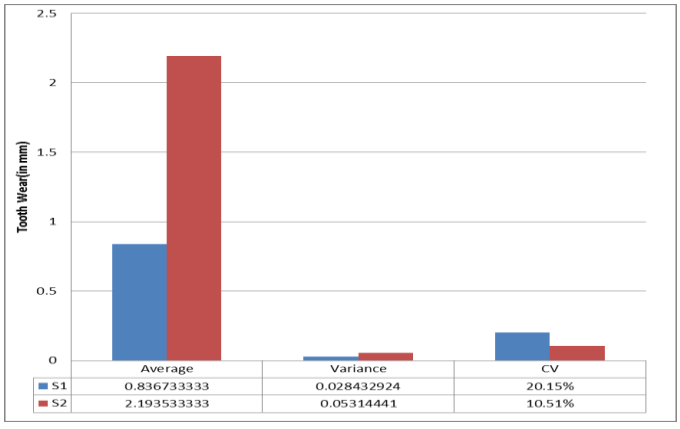

Figure 8

DISCUSSION

The aim of our present study was to investigate the loss of enamel due to erosion and abrasion because of regular consumption of carbonated beverages and to determine the abrasive potential of commercially available toothpastes in addition to additive effects of enamel loss due to combined effects of beverages and toothpastes. We had also stated a hypothesis that there is a positive enamel loss due to erosion by beverages and abrasion by toothpastes.

In our study, 150 extracted teeth specimens were put to various test regimes to evaluate the effects of tooth

wear by carbonated beverages and toothpastes. Our study revealed the positive enamel loss which was in concurrence with the previous studies done alone similar pattern. [19,20,22,23,24]

In Group A, 75 samples were put under erosive tests in beverages. As can be seen in Table 1, beverage B2 was the most acidic (pH 2.5-4.2) while beverage B4 was detected to have the lowest range (pH 3.4-4.6) among the test group. The synthetic saliva was found to range between weakly acidic to weakly alkaline (pH 6.2-7.4).

The samples were eroded and then profiled. The differences in the baseline measurement and final measurement were noted. It can be appreciated from Table 3 that control group (B1) has the least tooth wear (mean value=0.00802). Beverage B2 showed the highest tooth wear among all the groups (mean value=0.578333). From table 6, it can be observed that significant differences are present between the control group (B1) and the test groups (p<0.0001). Also, significant differences was seen between groups B2 and B3, B4 and B5 (p<0.0001). However, no significant difference was seen between groups B4 and B5 (p>0.05). Also, the mean erosion of groups B4 and B5 were close to each other (0.06 and 0.05mm respectively).

From Graph 1, it can be seen that among all the beverages in the test groups, B2 was the most erosive while B5 eroded the least.

In Group B, 75 samples were abraded using a customized brushing machine and toothpaste slurry. Again, the differences in the baseline measurement and the final measurement were noted. From Table 9, it can be seen that control group (T5) has the least tooth wear (mean value=0.0105) while toothpaste T2 showed maximum tooth wear (mean value=0.6810). From Table 3, it can be seen that significant differences are present between the control (T5) and test groups (p<0.0001). It can be appreciated that no significant difference was seen between groups T1 and T3 (p>0.05). Furthermore, significant differences were seen between groups T1 and T2 and T4 (p<0.0001). Figure 2 shows that while T1 showed least abrasion, T2 abraded the most.

In group C, the most erosive beverage (B2) and the most abrasive toothpaste (T2) were seen for their synergistic effects (S2). Also, the control system of both the groups were chosen (S1). Table 4 shows the large degree of tooth wear caused by the synergistic effects in group S2. Significant amount of differences in the mean values of tooth wear between group S1 and S2 can be seen in Table 4. This shows the high tooth wear caused by the additive effects of erosion and abrasion.

Our study was in concurrence with the in situ study conducted by Hooper S et al.[19]

It is interesting to note that the harm done by abrasion by toothpaste alone is negligible compared to the additive effects. Hence, it is advisable to avoid drinking beverages prior to brushing.

Furthermore, our primary hypothesis that there is a positive enamel loss due to erosion by beverages and abrasion by toothpaste was in agreement with the results. Also, Indian herbal toothpaste T1abraded the least among all the toothpastes used in the study.

Though the study fulfilled its objectives, what remains to be answered is the evaluation of various other actions of toothpastes like plaque removal, stain removal as well as other aspects.

CONCLUSION:

In conclusion, our study suggests that the abrasion of enamel by most toothpaste alone is negligible. Similarly, with normal usage, abrasion of enamel by toothpaste alone should not reach clinically significant levels unless there are abusive oral hygiene habits. Tooth wear of enamel is enhanced by the combination of soft drink erosion and toothpaste abrasion. These data are supportive of advice to avoid tooth brushing immediately following the consumption of acidic beverages.

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