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# The Comparison of Different Cleansing Methods on Acid Eroded Teeth

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## Abstract

The aim of this *in vitro* study was to evaluate the influence of different tooth cleansing methods on acid eroded teeth. Fifty enamel specimens were prepared from unerupted third molars and then randomly assigned into 5 groups. All specimens were eroded by pure orange juice for 5 minutes. Group A was not cleaned. Group B was cleaned (control group) by deionized water. Group C was cleaned by 0.05% sodium fluoride mouthwash. Group D was brushed immediately with an electric toothbrush with a fluoride toothpaste slurry. Group E was kept for 60 minutes in artificial saliva then treated with the same method as group D. During the experiment, all specimens were stored in artificial saliva and tested 3 times a day for 20 days. Lesion depth was recorded using a profilometer before and after treatment. The results showed that groups C, B, E and D had statistically lower lesion depths than the control group ($p < .5$). Group C had the lowest lesion depth while groups B, D and E showed no significant difference. Group A was significantly greater in lesion depth than all other groups. It was concluded that cleansing teeth after contact with acid can reduce erosion. However, the use of 0.05% sodium fluoride mouthwash after consuming acidic drink was shown to reduce erosion most effectively.

**Key words:** acidic drink; beverage; erosion; fluoride; tooth cleansing method

## Introduction

Nowadays, potential risk factors for dental erosion come from changing life style and eating patterns, with increased consumption of acidic food and beverages.[1,2,3] Healthier diets include the consumption of fruits and vegetables (a lactovegetarian diet) which can be associated with a higher prevalence of dental erosion.[4,5] The restoration of dental tissues destroyed by erosion is complicated and expensive, thus prevention is the best option.

Kelly and Smith[6] found that erosion alone produced nearly six times as much loss of tooth substance as abrasion alone, and the two in combination. They concluded that the application of human saliva, an artificial calcifying solution, and a fluoride mouthwash after exposure to the erosive solution and before brushing, were ineffective in reducing the amount of tooth wear. This is in contrast with the findings of Attin, Zirkel and Hellwig[7] that an application of the fluoride solution increased wear resistance of the eroded dentin specimens, with a significantly better protection by the high fluoride concentration (2,000 ppm) compared to the low fluoride concentration (250 ppm) solution. They suggested that an application of 2,000 ppm sodium fluoride solution immediately before toothbrushing significantly reduced abrasion of eroded dentin *in vitro*. According to Sorvari *et al*[8], treatment of enamel with topical fluoride (fluoride varnish and/or solution) prior to an acidic challenge could inhibit initial erosion.

An *in vitro* study of Bartlett, Smith and Wilson[9] showed that less wear was produced in the presence of fluoride toothpaste than non-fluoride toothpaste. They suggested that the prolonged application of a high-concentration of fluoride ions during the abrasive component had topical effect, which reduced the solubility of enamel during the erosive episode. According to Milosevic[10], routine use of topical fluoride in the form of toothpaste or mouthwash may reduce mineral loss and promote remineralization in fluoroapatite. However, Kuroiwa *et al*[11] showed that brushing without dentifrice induced the remineralization of acid etched enamel by salivary components deposition, while paste brushing could lead to abrasion of the weakened enamel. Yet this study did not use non-fluoride toothpaste so there was no effect of fluoride.

Hu *et al*[12] concluded that fluoride-toothpaste could promote the remineralization of etched enamel and enhance its resistance to acid attack by means of a scanning electron microscope. According to Munoz *et al*[13], remineralizing toothpaste and sodium fluoride toothpaste significantly alleviated the reduction of tooth hardness due to acid soft drink exposure. Newby *et al*[14] demonstrated fluoride toothpaste can increase the protection of enamel against an erosive challenge *in vitro*, and that the increase protection correlated with fluoride uptake. Jaeggi and Lussi[15] found that immediate toothbrushing after consuming acidic drink can erode enamel more than brushing 30 or 60 minutes later. They suggested delayed brushing for 60 minutes after consuming acidic food.

Many researches have attempted to find methods to prevent erosion or whether these methods can reduce erosion, or which method is the best. But no research has compared the effectiveness of routine oral hygiene practices such as rinsing with water, rinsing with fluoride and toothbrushing with fluoride toothpaste after teeth contact with acid.

The aim of this *in vitro* study was to compare the effects of rinsing with water, rinsing with 0.05% sodium fluoride mouthwash, immediate toothbrushing and 60 minutes delay before toothbrushing with 1,000 ppm fluoride toothpaste on acid contacted teeth.

## Materials and Methods

### *Preparation of the specimens*

Fifty unerupted third molars were cleaned with pumice and the roots were removed with water-cooled carborundum disc. Then each tooth was embedded in acrylic resin block with its buccal surface expose at the same level as the surface of acrylic resin block. The enamel surface was flatten and smooth using 1,200 grit abrasive paper to exposed approximated enamel area of 10 $mm^2$. The baseline profile of the enamel surface of all specimens were traversed by 5 µm radius diamond stylus loaded with 0.4 mN of a profilometer (Surfcorder model SE-2300, Kosaka Laboratory Ltd. Tokyo, Japan). Samples with an average roughness value (Ra) of less than 0.4 µm were used in this study. Each specimen was coded with nail varnish twice except for an area of 1.5 mm x 2 mm which is a test or erosion areas in the center of the enamel surface. The area covered with nail varnish is considered a reference area.

### *Storage in Orange Juice and Cleansing Methods*

Five groups of 10 specimens were immersed in 100% pure orange juice (TIPCO Food Ltd., Thailand) (pH=3.5) which were used as demineralization solution for 5 minutes, then the specimens were subjected to 5 different cleansing methods as follows : A) control; B) rinsing with deionized water; C) rinsing with 0.05% sodium fluoride (NaF) mouthwash for 1 minute; D) brushing immediately with fluoride toothpaste slurry for 10 seconds and E) immersed in artificial saliva for 60 minutes then brushing with fluoride toothpaste slurry for 10 seconds. Groups D and E were performed with an electric toothbrush (Braun Oral-B Ultra Plague Remover D9511, 760 rev/min) with the load on its head was 100±5 g.

After each specimen was cleaned, it was then stored in artificial saliva which prepared similarly to the formulation of Mcknight-Hanes and Whitford[16] but was modified by the exclusive used of sorbital. The composition was composed of (grams per liter of deionized water) : methyl p-hydroxybenzoate, 2.0 ; Na-carboxymethyl cellulose, 10.0 ; KCl, 0.625 ; $MgCl_2 \cdot 6H_2O$, 0.059 ; $CaCl_2 \cdot 2H_2O$ , 0.166 ;

$K_2HPO_4$ , 0.804 ; $KH_2PO_4$ , 0.326. The pH was adjusted to 6.75 by using KOH. This experiment was repeated 3 cycles per day for 20 days.

***Lesion Depth of Enamel Analysis***

After 20 days, nail varnish was removed from the reference area by rinsing with acetone. The lesion depth of enamel in erosive area was determined with a profilometer. The diamond stylus moved from the reference area across the tested area and to the other reference area for distance of 4 mm. Three measurements were performed in the center of the erosive area with 0.5 mm intervals. The maximum depth of the erosive area relative to the reference area was recorded and averaged.

***Statistical Analysis***

One-way analysis of variance and multiple comparison (Scheffe) tests were used to compare the difference in the lesion depth between each group. Significance was set at $p \leq .05$.

## Results

The amount of enamel loss following cleansing with various methods was shown in Table 1. The amount of enamel removed ranged from 10.26 to 19.85 µm. The control group had the highest lesion depth, while the NaF mouthwash group had the lowest lesion depth. There was no statistically significant difference in erosion depth among the rinsing water group (B), the toothbrushing immediately group (D) and the toothbrushing after 60 minutes group (E).

## Discussion

This experiment used 100% pure orange juice as a substitute for an eroding substance because it contains citric acid found in fruits and vegetables.[17] Orange juice has a citric acid concentration of 1 percent (w/v) approximately. Citric is a strongly chelating acid that can chelate calcium ion from enamel[18] after exposed to a solution that has a lower pH than the critical pH (pH 5.1-5.5).[19,20] The pH of this pure orange juice was lower than the critical pH of hydroxyapatite crystals, which can erode enamel.

The results showed that the control group had the highest lesion depth. The other experimental groups which were cleaned after being eroded by pure orange juice had less lesion depths of enamel than the control group. It showed that these tooth cleansing methods can reduce erosion. Using 0.05% sodium fluoride mouthwash in this study was the most effective method, following by toothbrushing with 1,000 ppm fluoride toothpaste after waiting for 60 minutes and rinsing with water, respectively. An immediate toothbrushing was the least effective method.

In general, after enamel is contacted with acid, hydroxyapatite crystal will change into unstable dicalcium phosphate dehydrate.[20] It can be dissolved to free calcium and phosphate ions and appeared eroded lesion. If fluoride is applied during this stage, calcium and

***Table 1*** *Mean depth of enamel loss by type of treatment*

| Group | Treatment | Mean depth ± s.d.(mm) |
|---|---|---|
| A | Control | 19.85 ± 2.63[a] |
| B | Rinsing water | 14.79 ± 1.88[b] |
| C | NaF mouthwash | 10.26 ± 2.24[c] |
| D | Toothbrushing immediately | 16.39 ± 1.97[b] |
| E | Toothbrushing after 60 min | 13.73 ± 2.69[b] |

phosphate can remineralize to form fluoroapatite crystal or calcium fluoride, depending on fluoride concentration. Fluoride concentration is less than 1,000 ppm, an fluoroapatite could be formed. If the fluoride concentration was more than 1,000 ppm, calcium fluoride would be formed.[21] These formations occurred when the pH value of the solution and time are appropriated.[22]

In this study, the 0.05% sodium fluoride mouthwash group, which used low concentration of fluoride (227 ppm), showed least lesion depths of enamel. It may be described that the remineralization occurred in the form of fluoroapatite crystal corresponding with the study of Munoz *et al*[13] Fluoroapatite had more resistance to acid than hydroxyapatite because it had a lower critical pH (pH 4.5).[23,24] However, it cannot be indicated the substance formed because it was not further analyzed in this experiment.

Both of toothbrushing immediately group and the toothbrushing after 60 minutes group (1,000 ppm fluoride toothpaste). Thus showed lower mean depths than the control. It could be stated that the remineralization happened but it was not sufficient to resist the erosion. Toothbrushing initiated demineralization by the brushing method and the abrasive component in toothpaste. It may rub the enamel surface that had rough surface from erosion.[11,25] The lesion depth of both toothbrushing groups (group D&E) were greater than that of the NaF mouthwash group (group C), but less than that of the control group. In contrast with the study of Kelly and Smith,[6] they found that immediate toothbrushing after eroded by acid caused more worn enamel surface than that of no cleaning. Their study used non-fluoride toothpaste, therefore fluoride can reduce erosion.

The toothbrushing after acidic exposure for 60 minutes group (Group E) had a smaller lesion depth than the toothbrushing immediately group (Group D) because waiting for 1 hour in artificial saliva, eroded enamel was remineralized from calcium and phosphate ions in artificial saliva to make hardened enamel.[26,27,28] When brushing was delayed, the wear was less than that of immediate toothbrushing. This coincides with the study of Jaeggi and Lussi.[15]

Deionized water dilutes acid concentration, so it can reduce the erosive action of acid.[15] Besides, the use of artificial saliva during the experiment may help in remineralization but it cannot be compared to the use of fluoride.

A major advantage of this *in vitro* study is the ability to control time and material given for each specimen. However, there are variations of each tooth. Flattening and smoothing the outer enamel surface for profilometry results in loss of the natural outer enamel surface, which has more fluoride than the inner area. Therefore this technique reduces acid resistance of enamel. Thus, this *in vitro* study may find the lesion deeper than any *in vivo* study.

Moreover, it is difficult to create an oral environment in the experiment. Even though the study of Amaechi, Higham and Edgar[26,27,28] found that storing enamel in the artificial saliva had significantly less erosion than storing in the deionized water because it had a remineralization from calcium and phosphate in the artificial saliva. Nevertheless, there are many uncontrollable factors such as salivary pellicle that can protect enamel and reduce demineralization[13] and the oral clearance that can balance oral pH, which is different in each person. Meurman, *et al*[29] found that oral pH of the patients immediately declined after consuming acidic drink, and changed to normal pH 2-3 minutes later because of the buffering capacity of saliva. While Bashir and Lagelof[18] found that the clearance was completed in 1 minute after rinsing with citric acid.

## Conclusions

Within the limitations of an *in vitro* study, it might be concluded that orange juice can erode tooth and routine tooth cleansing methods such as rinsing with water, toothbrushing with fluoride toothpaste and using fluoride mouthwash can reduce erosion. Using 0.05% sodium fluoride mouthwash is the best method. Rinsing with water is an easy method that can reduce erosion more effectively than immediate toothbrushing but not statistically significant. It is conceived that one should wait for about 60 minutes before toothbrushing to avoid destroying weak enamel after consuming acidic drinks.

Further studies should investigate whether this is also true for the *in vivo* situation and should find an easy and more effective method to reduce dental erosion.

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## บทคัดย่อ

การทดลองนี้เปรียบเทียบวิธีการทำความสะอาดฟันที่สึกกร่อนจากกรด โดยใช้ฟันกรามแท้ซี่ที่สามที่ยังไม่ขึ้นจำนวน 50 ซี่ สุ่มแบ่งเป็น 5 กลุ่ม นำฟันทั้งหมดแช่ในน้ำส้มแท้นาน 5 นาที เพื่อให้เกิดการสึกกร่อน หลังจากนั้นแต่ละกลุ่มได้รับการทำความสะอาดด้วยวิธีต่างกัน คือ กลุ่ม A (กลุ่มควบคุม) ไม่ทำความสะอาด กลุ่ม B ล้างด้วยน้ำกลั่น กลุ่ม C แช่ในน้ำยาบ้วนปากที่มีส่วนผสมของ 0.05% โซเดียมฟลูออไรด์ กลุ่ม D ใช้แปรงสีฟันไฟฟ้าแปรงทันทีร่วมกับยาสีฟันชนิดฟลูออไรด์ กลุ่ม E นำไปแช่ในน้ำลายเทียมนาน 60 นาที แล้วทำเช่นเดียวกับกลุ่ม D ในระหว่างการทดลอง ตัวอย่างฟันทั้งหมดถูกเก็บไว้ในน้ำลายเทียม และนำมาทดลองวันละ 3 ครั้ง เป็นเวลา 20 วัน วัดการสึกของผิวเคลือบฟันที่เกิดจากการทดลองด้วยเครื่องวัดความหยาบผิว ก่อนและหลังการทดลอง พบว่ากลุ่มตัวอย่างฟันที่ทำความสะอาดเกิดการสึกมากกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ($p < .05$) โดยกลุ่ม C สึกน้อยที่สุด ส่วนกลุ่ม B E และ D ไม่แตกต่างอย่างมีนัยสำคัญทางสถิติ กลุ่ม A เป็นกลุ่มที่ผิวเคลือบฟันสึกมากที่สุด สรุปคือการทำความสะอาดฟันหลังสัมผัสอาหารที่เป็นกรดจะช่วยลดการสึกของฟัน และพบว่าการใช้น้ำยาบ้วนปากที่มีส่วนผสมของ 0.05% โซเดียมฟลูออไรด์ให้ผลดีที่สุด