EFFECT OF FIVE DIFFERENT DENTAL PRODUCTS ON SURFACE HARDNESS OF ENAMEL EXPOSED TO CHLORINATED WATER IN VITRO

Prphasri Rirattanapong¹, Kadkao Vongsavan¹ and Mullika Tepvichaisillapakul²

¹Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, Bangkok; ²Sirindhorn College of Public Health, Suphan Buri, Thailand

Abstract. The objective of this study was to assess the effect of five different dental products on surface microhardness of enamel exposed to chlorinated water in vitro. Sixty human sound premolar teeth, extracted for orthodontic reasons, were used and randomly divided into 6 groups (10 specimens each group: artificial saliva, 1,000 ppm fluoride toothpaste, CPP-ACP paste, CPP-ACP with 900 ppm fluoride paste, CPP toothpaste and tricalcium phosphate with 950 ppm fluoride paste. All specimens were immersed in chlorinated water at pH 5 for 24 hours and then remineralized by coating with a dental product from each group for 5 minutes and kept in artificial saliva at 37°C for 6 hours. The surface microhardness of the enamel was measured with a Vickers hardness tester at baseline, after erosion by chlorinated water and after remineralization. Comparisons of the mean microhardness within each group were made using a one-way repeated measures ANOVA and between groups using a one-way ANOVA and an LSD test at p < 0.05. The mean surface microhardness in all groups decreased significantly after eroding with chlorinated water and increased after remineralization. After remineralization, the mean surface microhardness of the artificial saliva group was significantly less than the other groups. Five different dental products (1,000 ppm fluoride toothpaste, CPP-ACP paste, CPP-ACP with 900 ppm fluoride paste, CPP toothpaste and tricalcium phosphate with 950 ppm fluoride paste) increased the hardness in vitro of eroded enamel caused by chlorinated water.

Keywords: chlorinated water, CPP-ACP, erosion, fluoride, microhardness, tricalcium phosphate

INTRODUCTION

Dental erosion is defined as a loss of tooth surfaces caused by intrinsic and extrinsic factors (Wiegand et al, 2004). Intrinsic factors include vomiting and gastroesophageal reflux. Extrinsic factors include exposure to acidic foods, drinks, medications or other lifestyle factors (Caglar et al, 2005).

There have been several case reports of competitive swimmers suffering dental erosion from swimming in gas-chlorinated pools (Centerwall et al, 1986). A pH of 5.5 is considered to be the critical pH for enamel dissolution. Chlorine is the chemical most often used to keep swimming pools free of bacteria. When chlorine is
added into water, it produces hypochlo-
rous acid (HOCl) and hypochloride ion
(OCl). Extremely high levels of chlorine
in the water cause a decrease in the pH
of the swimming pool water. In 2003, 139
swimming pools in 15 provinces of Thai-
land were examined by the Dental Public
Health Division, Department of Health, to
assess the risk of dental erosions among
swimmers; their results showed 31.2% of
swimming pools had a pH < 5.5, increas-
ing the risk to swimmers (Chanduaykit
et al., 2005).

Dental erosions are important in the
long-term management of the health of
teeth. It is important to search for agents
to prevent or repair of dental erosions.
Although there is convincing evidence of
the preventive effects of fluoride against
dental erosions and abrasion resistance
after an erosive attack (Lussi et al., 2004),
the following newer dental products claim
to prevent erosions: Tooth Mousse (CPP-
ACP), Tooth Mousse Plus (CPP-ACFP), Hi
Herb toothpaste (CPP) and Clinpro Tooth
crème (tricalcium phosphate).

The objective of the present study
was to evaluate the effect of five dental
products on the surface microhardness
of enamel exposed to chlorinated water
in vitro.

MATERIALS AND METHODS
Specimen preparation
This study was approved by the Ethic
Committee of Mahidol University. Sixty
sound premolars freshly extracted for
orthodontic purposes, were kept in 0.9%
normal saline and the radicular part of
each tooth were removed. The specimens
were embedded in self-cured acrylic resin.
The labial surfaces were ground wet using
400, 600, 1,200, 2,000 and 2,500 grit silicon
carbide paper to obtain flat and smooth
surfaces. Two millimeter square test win-
dows were demarcated by scalpel cuts to
assist in specimen orientation during the
surface microhardness test. Baseline sur-
face microhardness of the sound enamel
was measured on the labial surface using
a Vickers indenter (FM-700e Type D, Fu-
ture-Tech, Tokyo) with 100 grams of force
for 15 seconds (Moupomé et al., 1999). Four
indentations per test were performed on
each specimen during each experiment.

Erosion procedure
All specimens were soaked in chlo-
rinated water at room temperature for
24 hours. The chlorinated water was pre-
pared from Ca(ClO)₂ 3 mg dissolved in
3,000 ml tap water and adjusted to a pH
of 5.0 with 0.1 M HCl. All the specimens
were then rinsed in deionized water and
blotted dry. The Vickers Indenter Test
was performed, with indentations at least
120 µm apart, and the average of the 4
indentations was used as the microhard-
ness value.

Remineralization procedure
The specimens were randomly divid-
ed into six groups of 10 teeth each: Group 1
(control group) received no treatment,
groups 2,3,4,5 and 6, were treated with
a 0.5 mm layer of 1,000 ppmF, CPP-ACP,
CPP-ACP plus 900 ppmF, CPP, and
tricalcium phosphate plus 950 ppmF,
respectively, for 5 minutes (Table 1). All
specimens were stored at 37°C for 6 hours
in artificial saliva containing 0.65 grams
per liter potassium chloride British Phar-
macopoeia (BP), 0.058 g/l magnesium
chloride BP, 0.165 g/l calcium chloride
BP, 0.804 g/l dipotassium hydrogen
phosphate US Pharmacopoeia, 0.365 g/l
potassium dihydrogen phosphate, 2 g/l
sodium carboxymethyl cellulose BP and
deionized water to make 1 liter as modi-
ified from Amaechi et al (1999). After the
The specimens were washed with deionized water and blotted dry. The Vickers Indenter Test was performed, with indentations at least 120 μm apart, and the average of the 4 indentations was used as the microhardness value.

**Statistical analysis**

A one-way repeated measure analysis of variance (ANOVA) was used to compare the surface microhardness values at baseline, after erosion and after remineralization with significance set at $p<0.05$. The one-way ANOVA and least significant difference (LSD) were used to compare the mean surface microhardness values among the groups with a significance level set at $p<0.05$.

**RESULTS**

The mean surface microhardness values at baseline, after erosion and after remini...
remineralization are shown in Table 2. The mean baseline microhardness value was 343.82±13.92 VHN. One-way ANOVA revealed no statistically significant difference among the groups at baseline.

After erosion, one-way ANOVA results showed no statistically significant difference among groups. The average enamel microhardness was 310.31 VHN, a 9.76% reduction from baseline.

After remineralization, the mean microhardness values increased significantly compared to the mean microhardness values after erosion. The one-way ANOVA results show the microhardness value of the artificial saliva control was lower than the other dental products.

**DISCUSSION**

The baseline enamel microhardness value in this study was 343.87±14.14 VHN. This is similar to studies by Panich and Poolthong (2009) and Maupomé et al (1999) but higher than the studies by Seow and Thong (2005) and Wongkhantee et al (2006). The microhardness values may have been different due to differences in specimen preparation, area of the tooth and type of tooth used (Cuy et al, 2002).

After erosion with chlorinated water, the mean microhardness reduction was 9.76% below baseline. This reduction is different from a study by Chuenarrom et al (2010), in which the mean microhardness reduction was 23.2%. This difference may have been due to different pH levels or timing of the erosion process.

In this study, remineralization occurred in the artificial saliva group. The artificial saliva was produced using the formulation of Amaechi et al (1999). The artificial saliva contained potassium chloride, magnesium chloride, calcium chloride, dipotassium hydrogen phosphate and potassium dihydrogen phosphate, which may help remineralize enamel. Results from several studies have shown artificial saliva can reharden eroded enamel (Devlin et al, 2006; Lussi et al, 2008). However, the rehardening of the eroded enamel with artificial saliva was less effective than with the other dental products.

Remineralization by 1,000 ppm fluoride toothpaste, CPP-ACP, CPP-ACP plus 900 ppm fluoride, CPP toothpaste, tricalcium phosphate, resulted in equal levels of microhardness that were not significantly different among the groups. Application of fluoride to the enamel surface can cause remineralization. The results of this study are similar to studies by Magalhães et al (2008) and Moretto et al (2010) who found fluoride 1,000 ppm can reharden enamel.

The CPP-ACP complex acts as a vehicle for calcium and phosphate, transporting it to the tooth surface and localizing it in plaque and salivary pellicles (Reynolds et al, 2009). A reduction in pH results in a release of calcium and phosphate ions, which act to promote remineralization. Most studies of CPP-ACP have focused on caries; a few studies have shown that CPP-ACP can reduce erosion from chlorinated water (Vongsawan et al, 2010), reduce tooth wear from abrasion (Ranjikar et al, 2009) and can increase enamel hardness following erosive by soft drinks (Panich and Poolthong, 2009).

A study by Srinivasan et al (2010) showed both CPP-ACP and CPP-ACP with 900 ppm fluoride significantly remineralized softened enamel, and the CPP-ACP and fluoride combination had greater remineralization potential than CPP-ACP, but the result of our study showed no
significant difference between CPP-ACP and CPP-ACP plus fluoride. This may be due to a different study design.

There has been much interest in CPP as an anticariogenic and remineralizing agent. CPP is produced by enzymatic digestion of casein, generally by trypsin (FitzGerald, 1998). Recently, CPP was found to reduce caries incidence during a clinical trial (Rao et al, 2009) that found no difference between CPP and fluoride 1,190 ppm, similar to our study.

Tricalcium phosphate (TCP) is a new hybrid material created with a milling technique that fuses beta tricalcium phosphate and sodium lauryl sulfate or fumaric acid. When TCP comes into contact with the tooth surface and is moistened by saliva, the protective barrier breaks down making calcium, phosphate and fluoride ions available to the tooth. A study by Karlinsey et al (2009) showed an innovative form of tricalcium phosphate plus fluoride 225 ppm can remineralize softened enamel but there are no published studies of TCP with 900 ppmF.

The five different dental products (1,000 ppm fluoride toothpaste, CPP-ACP paste, CPP-ACP with 900 ppm fluoride paste, CPP toothpaste and tricalcium phosphate with 950 ppm fluoride paste) increased the surface microhardness of eroded enamel by chlorinated water in vitro.

REFERENCES


