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Erosion Effect of Acidic Drinks on Two Types of Glass Ionomer Cement

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ABSTRACT
Aims. To investigate the pH of selected acidic drinks (coke®, orange juice, pineapple juice, tamarind juice and blackcurrant juice) and their erosive effects on GIC restorations.
Materials and methods. This is an in vitro study involving 70 extracted teeth where half of them were restored with Fuji IX (GC Corp., Japan) and the other half with GlasIonomer FX-II (Shofu Inc., Japan) in a cavity on labial surface measuring 4mm in diameters and 2mm in depth. For each material, 7 samples in a group were immersed into five different types of acidic solutions which the pH had been measured. Depth of erosion at body and marginal of the restoration was measured using stereomicroscope (Leica, UK). The data were statistically analyzed with Kruskal-Wallis and Mann-Whitney test (P<0.05).
Results. The pH of coke, orange juice, pineapple juice, tamarind juice and blackcurrant juice are 2.58, 3.41, 3.83, 3.5 and 3.2 respectively with Coke displaying the most erosive effect at body of the restoration while orange juice exhibited the most erosive effect at the margin of the restoration. Mann-Whitney test showed significant difference in GIC erosion caused by different acidic drinks (p= 0.001). The marginal erosion depth was greater than the body erosion and Fuji IX eroded greater than GlasIonomer FX-II (p= 0.001).
Conclusions. Acidic drinks have erosive potential on GIC and show different erosion patterns where the depth of erosion was greater at the margin than at the body of the restoration.

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INTRODUCTION

Oral health campaigns worldwide have traditionally placed more emphasis on advising the public about the dangers of sugary foodstuff that can cause caries. However, these campaigns seldom highlight the effects of acidic products such as fruit juices ‘sour pickles, carbonated drinks which can cause teeth erosion. Acid erosion of teeth has been described since 1808[1] and was defined as mineral loss from the tooth surface due to the chemical process of acidic dissolution involving acids not of bacterial origin.[2] Glass ionomer cement (GIC) has been widely used in restoring erosion lesions due to its favourable properties such as fluoride release. They were formed from the reaction of an ion-leachable calcium aluminosilicate glass powder containing fluoride and polyalkenoic acid.[3] While we are aware that these acidic drinks can cause teeth erosion, the effects on restorative materials are less apparent. In 1972, Sognnaes et al.[4] examined a random sample of about 10,000 extracted teeth and found that 1,700 teeth (18%) had typical patterns of erosionAnother study based on five months of observation estimated the erosion advancement rate as approximately 7µm a week for untreated and fluoride-treated teeth.[5] The National Child Dental Health Survey (2003) in the United Kingdom which assessed prevalence of deeper dental erosion (pulp and dentin) in five and six years old children, found the figure to be 23 %[1]. Severe dental erosion can lead to tooth hypersensitivity, tooth fracture and even can cause inflammation to the pulp and subsequently lead to non-vital tooth. Non- prepared cavity for restoration is the best method for preservation of both tooth structure and pulp vitality.[5] A clinical trial study done within 3 years in London showed that only Vshaped erosion lesions are the most favourable sites for restoration with GIC where no cavity preparation is contemplated.[5]. GIC is the commonest and easiest material to be used for erosion lesion.[5,6,7] The reasons are, this acid-base cement has mechanical and chemical bonding with enamel and dentin by adsorption of polyfunctional carboxylic acids to hydroxyapatite via chelating to calcium ions at the surface of hydroxyapatite and tight bound between polyacrylate ions with water molecules.[7]

Unfortunately, studies reported that acidic condition can degrade GIC.[2,3] Result of a study that used diluted acetic acid to examine surface morphology changes and formation of leached layer in GIC show formation of peak to valley and rounded smooth morphological surface due to corrosive effect, but its effect was slowed down by the leached layer which can reduce dissolution rate of GIC after 48 hours of immersion.[7] A study in London done in 2004 found that conventional GIC dissolved completely in apple juice and orange juice, but survived in Coca-Cola with a significantly reduced of hardness after 1 year.[8] However, another study in Thailand (2006) showed no change in surface hardness of GIC after immersion in carbonated drinks, on the contrary they showed that Coke®, made significant changes on resin modified glass ionomer cement[2] rather than GIC. Other studies used diluted acid solution (acetic acid, citric acid, phosphoric acid hydrochloric acid) and showed that GIC are more susceptible to the effect of low pH solution.[3,9] Limited number of studies have so far been done regarding the effects of acidic drinks on GIC erosion especially the acidic drinks that are commonly consumed in Malaysia.

The aim of this study is to identify the pH and effect of selected acidic drinks commonly consumed by Malaysian people on erosion of conventional GIC.

MATERIALS AND METHODS

This was a laboratory experimental study. Seventy sound, intact and restoration-free human incisors and premolars which have at least 5mm width of labial surface were selected for this study. Calculi were carefully removed and the teeth were stored in 10% formalin at room temperature until used. Two types of conventional GIC were investigated in this study which were Fuji IX (GC Corp., Japan) and GlasIonomer FX-II (Shofu Inc., Japan). Five types of acidic beverages commonly consumed by Malaysians i.e: Coke®, orange juice, pineapple juice, tamarind juice and blackcurrant juice were investigated for their erosive effect. This was a preliminary study with a sample size of 7 for each group.

Standardize 'U' shaped circular cavity with 4mm in width diameter and 2mm depth on labial surface of the tooth was prepared using straight fissure diamond bur and measured using periodontal probe. The teeth were stored in thymol water at 370 C as storage medium.[10] The cavities were then treated with a dentinl conditioner (GC Corp., Japan) for 10 seconds followed by placement of Fuji IX (GC Corp., Japan) for 35 samples and other samples with GlasIonomer FX-II (Shofu Inc., Japan) following the manufacturer's instructions. After 24 hours, the restorations were polished with soflex discs followed by nail varnish painted to within 2mm of the restoration to differentiate area of enamel that will contact with acidic solution and the covered area.[3] Impression of the restoration surface were taken with Dent Sillicone Plus (putty type) (Shofu Inc., Japan).

The samples were randomly divided into five groups of 7 samples according to the five types of erosive solutions which they were immersed in 40ml acidic drink solution for 16 hours.[3] The samples were washed using distilled water and sectioned buccolingually using hard tissue cutter (Exact, Japan). The teeth were then readapted accordingly on the impression taken previously and the excess was removed with scalpel blade. The distance between the impression and the body or margin of the restoration was measured under stereomicroscope (Leica, Germany). The pH of the acidic beverages was measured using a pH meter (Hanna Instrument, USA). All preparations for specimens, etching, restoration, impression and measurement procedures were conducted by the same clinician to reduce variability.

The data collected was analyzed using SPSS version 12.0 (SPSS Inc, 2003). Kruskal-Wallis, Mann-Whitney and Wilcoxon signedrank test analysis was used to detect significant differences in erosion at body and margin among the material and erosive solutions.

Ethical clearance was obtained from the Research and Ethics Committee, Universiti Sains Malaysia (FWA reg. no:00007718)

RESULTS

The pH of coke®, orange juice, pineapple juice, tamarind juice and blackcurrant juice are acidic as shown in Table 1 within a range of pH 2.58 to 3.83. Both tested materials were significantly eroded by the acidic drinks up to different extents after 16 hours of immersion. In general, the erosion at the margin of restoration is more than at the body of the restoration (Table 2). Both tested GIC erode greatly in Coke® (pH 2.5) for body erosion while marginal erosion depth showed greatly in orange juices (pH 3.41). Pineapple juice (pH 3.83) caused the least erosion for both brand of GIC.

Table 1. pH of acidic drinks

Acidic drinks	pH
Coke®	2.58
Orange juice	3.41
Pineapple juice	3.83
Tamarind juice	3.50
Blackcurrant juice	3.20

The Kruskal-Wallis test revealed statistically significant difference (p= 0.003) of body erosion depth and (p= 0.017) for marginal erosion depth of Fuji IX between the different types of acidic drinks (Table 3). GlasIonomer FX-II also show statistically significant difference (p= 0.001) of body and marginal erosion (Table 4). Further analysis by Mann-Whitney test was undertaken to compare the different subgroups where statistically significant difference was found between these subgroups.

Table 5 showed the significant different of erosion depth at the body and marginal of restoration and Fuji IX eroded more compared to FX-II (p= 0.001). The Wilcoxon Signed Ranks test showed that significantly different (p= 0.001) deeper erosion depth at the marginal restoration than the body of the restoration (Table 6).

DISCUSSION

Acidic conditions had been known to cause erosion of the enamel and extrinsic acid especially dietary acids are the most common causes of dental erosion.[10] However this study was more concerned with their effects on dental restoration (GIC). The drinks selected showed an acidic pH which pH ranges similar to previous study.[11]

Table 2. Median of depth of erosion at body and marginal of Fuji IX and GlasIonomer FX- II after immersion in acidic solutions

		Median (µm)	
Materials	**Acidic drinks**	**Body erosion**	**Marginal erosion**
Fuji IX	Coke®	120.061	119.80
	Orange juice	85.987	182.150
	Pineapple juice	50.007	93.445
	Tamarind juice	61.732	130.533
	Blackcurrant juice	46.617	100.820
GlasIonomer FX-II	Coke®	104.870	147.820
	Orange juice	45.376	170.520
	Pineapple juice	18.401	73.624
	Tamarind juice	23.475	116.210
	Blackcurrant juice	57.424	86.350

The result demonstrated that all solutions investigated have erosive effects but not in proportionate with the pH of the acidic drinks. Coke caused the most erosion in GIC, similar to the result in a study done by Aliping-McKenzie et al.[8] Coke® consists of phosphoric acid, while orange and pineapple juices consists of ascorbic and citric acid respectively, tamarind acid is classified as hydrocytric acid and blackcurrants juice is an ascorbic acid. Regarding acidity strength that caused erosion, it is not only depends on the amount of acid present in the solution (H+ ion concentration as measured by pH), but also depends on the amount of acid available (the titratable acidity), the strength of the acid (ease of dissociation as expressed by the acid dissociation constant, pKa), the buffering capacity (a solution's ability to resist change of its pH)1 and also chelating function of the acid. pKa of phosphoric acid, citric acid and ascorbic acid are 2.12, 3.15 and 4.2 accordingly. Coke was found easier to neutralize than orange juice.[2] Total acid level or titrable acid is thought to be an erosive potential more than the pH of the solution, which explained that erosion lesion depends on actual hydrogen ions available to interact with the tooth surface.

Table 3. Comparison erosion effect of acidic drinks on Fuji IX

Variable	Acidic drinks	*n*	Median (IQR)	X^2 statistic (df)[a]	P value [a]
Body erosion	Coke®	7	120.061 (91.886)	16.095 (4)	0.003
	Orange juice	7	85.987 (17.780)		
	Pineapple juice	7	50.007 (46.006)		
	Tamarind juice	7	61.732 (53.386)		
	Blackcurrant juice	7	46.617 (34.272)		
Marginal erosion	Coke®	7	119.80 (90.100)	11.997 (4)	0.017
	Orange juice	7	182.150 (77.660)		
	Pineapple juice	7	93.445 (49.650)		
	Tamarind juice	7	130.533 (124.180)		
	Blackcurrant juice	7	100.820 (137.830)		

[a] Kruskal-Wallis test

Table 4. Comparison erosion effect of acidic drinks on GlasIonomer FX-II

Variable	Acidic drinks	*n*	Median (IQR)	X^2 statistic (df)[a]	P value [a]
Body erosion	Coke®	7	104.870	24.384 (4)	0.001
	Orange juice	7	45.376		
	Pineapple juice	7	18.401		
	Tamarind juice	7	23.475		
	Blackcurrant juice	7	57.424		
Marginal erosion	Coke®	7	147.820	26.339 (4)	0.001
	Orange juice	7	170.520		
	Pineapple juice	7	73.624		
	Tamarind juice	7	116.210		
	Blackcurrant juice	7	86.350		

[a] Kruskal-Wallis test

Table 5. Comparing of erosion of Fuji IX and GlasIonomer FX-II

Variable	Fuji IX *n*=7 Median (IQR)	GlasIonomer FX-II *n*=7 Median (IQR)	Z statistic[a]	P value [a]
Body erosion	70.810 (47.361)	35.532 (47.270)	-4.45	0.001
Marginal erosion	130.533 (99.430)	93.000 (144.160)	-2.06	0.040

[a] Mann-Whitney test

Table 6. Comparing of body and erosion of Fuji IX and GlasIonomer FX-II

Variable	Body erosion Median (IQR)	Marginal erosion Median (IQR)	Z statistic[a]	P value [a]
Fuji IX	70.810 (47.361)	130.533 (99.430)	7.90	0.001
GlasIonomer FX-II	35.532 (47.270)	93.000 (144.160)	6.21	0.001

This study also showed GlasIonomer FX-II having less erosion compared to Fuji IX. Thismay be due to formation of leachable layer that can inhibit degradation of the material and ability to reduce the acidity of the acidic solutions.[7] This phenomenon has strong relationship with the potential of releasing fluoride of certain material. The ability in releasing fluoride not only varies between different restorative materials but also within brand. Optimal fluoride release is related to their matrices, setting mechanism of fluoride content and also on environmental conditions.

As GlasIonomer FX-II is a relatively new brand of conventional GIC, no previous studies using it was found and comparisons could not be done. Other factor such as methods used to prepare the restoration also can influence the outcome. The ratio of powder:liquid preparations may vary the strength of the restoration. If the powder:liquid ratio is reduced, the smooth, creamy paste will result in a slower setting.

As it is weak cement, dissolution is more susceptible to occur. The use of capsule dispensing method for GIC is advisable to reduce the operator error during mixing process Marginal erosion depth was greater than the body erosion which is similar with previous study.[3] The real causes for such feature is not well known; one of the expected was maybe due to marginal microleakage.

GIC are known to release a variety of matrix- forming ions depending on the chemical composition of the glass employed in their fabrication and it becomes greater in acidic condition.[12] Nourmohammadi et al,[7] did mention that the steadily reducing gains in mass in lactic acid with time can be attributed to an initial substantial gain in mass due to water sorption and a subsequent erosion due to effects of the acid.[6]

This phenomenon leads to the reduction in surface hardness of the restoration. Incorporation of casein phosphopeptide amorphous calcium phosphate or bioactive glass into GIC could increased the resistant to acid challenge.[12] The effect from erosion occur more at the margin than at the body might be misinterpreted as secondary caries.[13]

Clinically, we would expected that GIC restorations done in patient with high frequency of acidic drinks intake will have greater risk of restoration failure. Therefore the choice of filling materials should also consider a patient's dietary habits. 'Sandwich technique' a restorative technique whereby GIC is used as a base and covered with other acid-stable materials such as composite resin might be a good option. Future studies should also consider other factor such as saliva and its buffering capacity.

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