

Effect of Cola on Surface Microhardness and Marginal Integrity of Resin Modified Glass Ionomer and Compomer Restoration – An *in vitro* Study

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Abstract:

This study was carried out to evaluate the surface microhardness and marginal integrity of a resin modified glass ionomer and a compomer after immersing them in a cola soft drink for variable periods of time. The study was conducted in two parts. Forty two standard class V cavities were prepared on extracted human premolars, restored with Dyract AP and Fuji II LC and evaluated for marginal integrity. Forty two circular discs (CDs) were prepared with Dyract AP and Fuji II LC to test microhardness. These specimens were immersed in a cola drink under low, medium and high immersion regimes. Marginal integrity was analyzed using stereomicroscope and surface microhardness was evaluated on the circular discs using a microhardness tester. Statistical analysis revealed that the marginal integrity was least affected in low and medium immersion regimes and highly affected under high immersion regime. Surface microhardness was least affected in low immersion regime, while, medium and high immersion regimes showed appreciable softening of both restorative materials evaluated.

Key Words: Resin modified glass ionomer, polyacid modified resin composite, cola, low pH.

Introduction:

Glass ionomer cements are becoming increasingly popular in pediatric dentistry. Glass ionomer cements were first introduced to the dental profession by Wilson & Kent in 1972 (Wilson, 1991). As a restorative material, their sensitivity to moisture, low mechanical strength and wear resistance make them less durable (Hse et al, 1999). Rapid developments in the field of hybrid resin ionomer restorative materials led to the development of light cured glass ionomers and polyacid modified resin composite. The light cured glass ionomers were developed chiefly to overcome the problems of moisture sensitivity and low early mechanical strength, at the same time maintaining their clinical advantages. Their command set facility and fluoride releasing properties have made them very popular.

Compomers, as the name implies, combine the characteristics of both composites and glass ionomers into a single component. But it shows minimal glass ionomer reaction and so a more preferred nomenclature for this material is “polyacid modified resin composites” (McLean et al, 1994). The rapid acceptance of these new resin ionomer hybrid restorative materials by the dental profession was largely due to their ease of use (Hse et al, 1999).

Over the last few decades, the prevalence of

erosion seems to have increased presumably due to increased consumption of soft drinks and fruit juices (Nunn, 1996). Marketing of soft drinks traditionally has been directed at the younger generation by associating these beverages with peer group acceptability (Shaw & Smitha, 1999).

More recently, these drinks have also been promoted as healthy and linked to high profile sportsmen and celebrities. Erosion is linked to high intake, frequency and method of consumption of acidic beverages (Kelleher & Bishop, 1999). Excessive contact of the tooth structure with acidic food leads to loss of dental hard tissues. It can be assumed that restorative materials are also subjected to low pH values in the oral cavity by erosive attacks, leading to a degradation of the surface integrity (Kelleher & Bishop, 1999; Attin et al, 1997).

The glass component of these materials can react at acidic pH level (Zero, 1996). The presence of acids may cause surface changes of these materials (Zero, 1996) as phosphoric acid is a common constituent of cola soft drinks (Kula et al, 1996; Rytömaa et al, 1988).

It is also of great interest to obtain information on the behavior of these restorative materials under a range of pH conditions. There is no literature reporting on the effects of acidic pH due to cola consumption on the marginal integrity and surface microhardness of these newer hybrid glass ionomers. Considering the above aspects the present study was designed and carried out to evaluate the effect of Cola on a) marginal

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integrity & b) surface microhardness of Dyract AP (Polyacid modified composite resin) and Fuji II L.C (resin modified glass ionomer restorative material).

Materials and Methods: The present study was conducted in two phases:

Phase I: Microleakage study on standard class V cavities prepared in 42 extracted sound human premolars and restored with Dyract AP and Fuji II L.C restorative materials.

Phase II: Surface microhardness study on standard 42 circular discs (CDs) prepared with Dyract AP and Fuji II L.C restorative materials.

Phase I :

a) Preparation of samples for microleakage study:

Forty two extracted non-carious human premolars were stored at room temperature in 0.02% thymol solution. Teeth were scaled, cleaned with water and pumice in a rubber prophylaxis cup at low speed and examined for the presence of any craze lines and cracks that could have influenced dye penetration (Bouschlicher et al, 1996).

Buccal Class V cavities were prepared using a straight fissure diamond bur in high speed air-rotor handpiece under water spray with the dimensions of prepared cavity being at least 3 x 2mm and depth of 2mm (Bouschlicher et al, 1996). Cavities were placed 1mm coronal to Cemento Enamel Junction (CEJ; Hall et al, 1993). Forty two teeth thus prepared were divided into two equal groups for Dyract AP and restoration and for Fuji II LC restoration.

For Dyract AP restorations, the cavity walls were etched with 36% phosphoric acid gel, treated with Prime & Bond 2.1; single compound was syringed into the cavity and light cured for 40 seconds. For Fuji II LC restoration, the cavity walls were conditioned with GC dentin conditioner (20% polyacrylic acid) for 10 seconds and following the manufacturers instructions the powder/liquid proportion were mixed and placed in the cavity and light cured. Immediately after light curing, both groups of restorations were finished using water cooled fluted carbide bur and polished using abrasive disc (Sof-flex), which were used wet. After finishing, the restorations were lightly air dried, unfilled resin applied and cured.

Forty two restored teeth were kept in 100% humidity at 37°C for 24 hours. On removal of the restored teeth from the humidity chamber after 24 hours, they were



Fig. I: Microhardness testing unit.

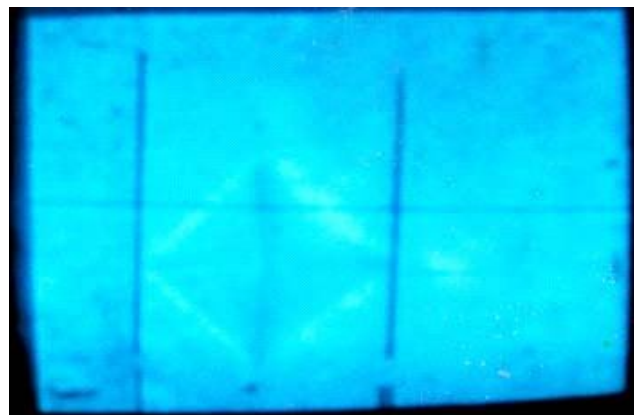


Fig. II: View of indentation.

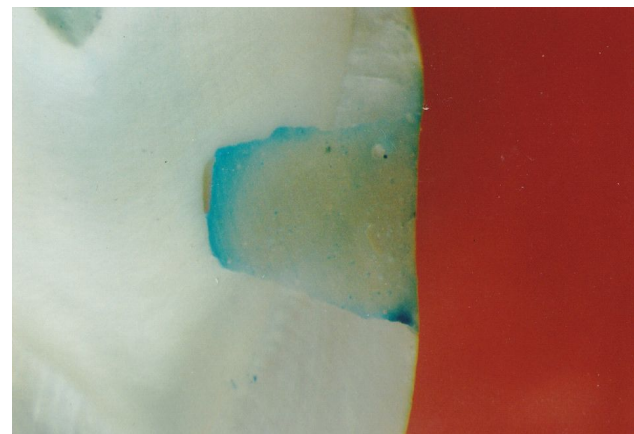


Fig.III: High immersion group of Fuji II L.C.—Score 3.

divided into 3 groups. All specimens were maintained in deionized water until the time of testing.

b) Immersion Regimes:

Six air tight plastic containers were taken; seven restorations of each material from individual immersion groups were placed in one plastic container and carefully labeled. Each of the plastic containers was filled with 25 ml Cola solution (Coke-Cola) for 5 minutes (Maupomé et al, 1998). Fresh Cola was used for each immersion. Low immersion regime was

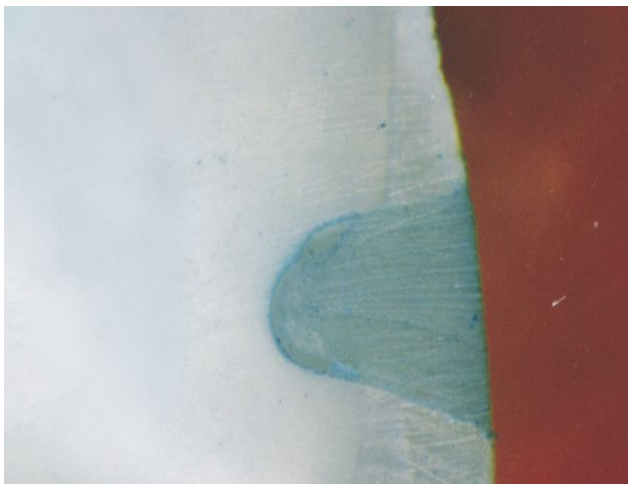


Fig. IV: High immersion group of Dyract AP—Score 3.

subjected to one immersion per day & medium regime to five immersions per day evenly distributed over 12 hours period. The high immersion regimes were subjected to ten immersions per day evenly distributed over 12 hours period, each day for seven days (Staninec & Holt, 1988).

Before and after each immersion in the Cola, the restorations were copiously rinsed in 0.1 M phosphate buffered saline (PBS) with pH 7.2. When not exposed to the drink, the restorations were stored in deionized water at room temperature (Maupomé et al, 1998).

At the end of test duration, the apices of the tooth were sealed with sticky wax and all tooth surfaces except a 1mm wide zone around the margin of each restoration were painted with nail varnish.

The teeth were then immersed for 4 hours in 10% solutions of methylene blue dye (Brackett et al, 1995; Ferrari et al, 1996), rinsed, dried and invested in clear resin. Each tooth was sectioned bucco-lingually through the center of the restoration with the help of a low speed water cooled diamond disc. The specimens thus obtained were examined under stereomicroscope to evaluate the microleakage and dye penetration scores. The scoring criteria was similar to that used by Staninec & Holt (1988).

Phase II:

a) Preparation of samples for microhardness: Forty two circular discs were prepared with Dyract AP and Fuji II LC restorative materials using brass mould having inner diameter of 6.5 x 2 mm thickness.

Dyract AP material available in single component was syringed into the brass moulds. For Fuji II LC following manufacturers instructions the

powder/liquid proportions were mixed and placed in the brass mould and cured and were covered with matrix strips on either side.

For both Dyract AP and Fuji II LC circular discs, no finishing or polishing procedure was required because the surfaces were cured against a matrix (Frazier et al, 1998). Then on each side of circular discs unfilled resin was applied and light cured (Ferrari & Davidson, 1996).

All the circular discs were kept in 100% humidity at 37^o C for 24 hours. On removal of the pellets from the humidity after 24 hours, the pellets were divided into three equal groups and each pellet was assigned a test tube and carefully labeled containing deionized water until the time of testing.

b) Base line study of microhardness:

The circular discs were stabilized on plastic plate with the help of adhesive tape and placed on the test base of the SHIMADZU HMV- 2000 microhardness tester. The testing parameter was 100 gm for 15 seconds (Cattani-Lorente et al, 1999; Gladys et al, 1997; Attin et al, 1996). The square based diamond pyramidal indentation so formed was measured on display monitor and measuring unit displayed the Vickers hardness numbers (VHN).

The second indentation on the same specimen was done at least 100 mm apart from the first indentation and procedure was repeated. If the 1st and 2nd indentation differed by more than 5 units, a 3rd indentation was taken. Otherwise, 1st and 2nd indentation was averaged as VHN for those individual circular discs .

All the circular discs were subjected to immersion regimes similar to the microleakage study.

c) Final microhardness testing:

After the end of test duration, the pellets were re-tested under microhardness testing machine in a similar way as baseline study and these values was noted on the table as final VHN value of each pellet. The values obtained as base line and final VHN for each pellet were subjected to statistical analysis.

Results:

The mean and standard deviation were calculated for the comparison of microleakage score of Dyract AP and Fuji II LC (Table I). In low immersion regime, both Dyract AP and Fuji II LC showed zero microleakage score and in medium immersion regimes one sample of Dyract AP group showed microleakage

score of three (0.43 ± 1.13) while two samples of Fuji II LC group showed micrleakage score of one (0.29 ± 0.49). In high immersion regime all samples of both Dyract AP and Fuji II LC showed micrleakage score of 3 (mean 3.0; Fig. III & IV).

Baseline and final values of surface microhardness for Dyract.

Table No. I: Microleakage Score of Dyract AP and Fuji Ii L.C

Materials	Immersion	Microleakage Score				Mean Score \pm S.D.
		0	1	2	3	
Dyract AP	Low	7	-	-	-	0.0
	Medium	6	-	-	1	0.43 ± 1.13
	High	-	-	-	7	3.0
Fuji II L.C	Low	7	-	-	-	0.0
	Medium	5	2	-	-	0.29 ± 0.49
	High	-	-	-	7	3.0

Table No. II: Comparison of Surface Microhardness between Baseline and Final values expressed in VHN.

Material	Immersion Group	Base Line		Final		Differ-ence *	% redu-ction	p-value **
		Mean	SD	Mean	SD			
Dyract AP	Low	24.64	2.50	23.32	2.39	-1.32	5.4%	NS
	Medium	27.72	2.34	21.91	5.96	-5.81	20.9%	$p < 0.01$
	High	29.50	4.74	22.54	2.40	-6.96	23.6%	$p < 0.01$
Fuji II L.C	Low	51.67	7.67	46.19	9.93	-5.48	10.6%	NS
	Medium	41.97	10.78	26.21	4.53	-15.76	37.5%	$p < 0.01$
	High	53.72	9.13	33.13	2.59	-20.59	38.3%	$p < 0.01$

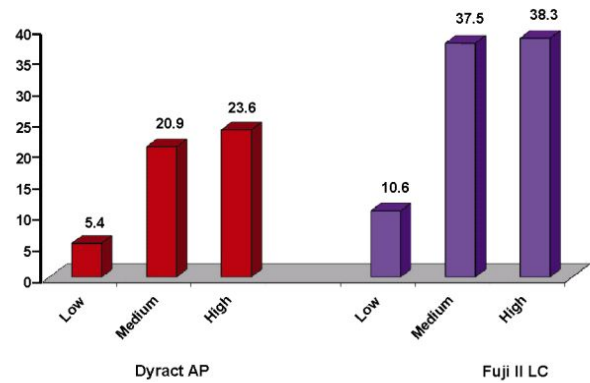
* -ve sign indicates reduction in surface microhardness
 ** Mann-Whitney U-test.

AP and Fuji II under low, medium and high immersion were compared. In the low immersion regime both the evaluated materials showed no significant reduction in microhardness, while Dyract AP showed 20.9% and 23.6% reduction in microhardness under medium and high immersion regimes respectively, which was statistically significant ($p < 0.01$). Similarly, Fuji II LC showed 37.5% and 38.3% reduction in microhardness under medium and high immersion regimes respectively (Fig.V) which was statistically significant ($p < 0.01$). Comparing Dyract AP & Fuji II LC groups, statistically significant difference was observed between the two in all the three regimes. There was also statistically significant difference ($p < 0.01$) between low and medium as well as low and high immersion regimes. However, there was no statistically significant difference between the medium and high immersion regimes.

Table III: Comparison of changes in surface of microhardness between various immersion groups.

Immersion	Difference between base line and final VHN				
	Dyract AP		Fuji II LC		Difference between material in each immersion
	Mean Diff.	% Reduc-tion	Mean Diff.	% Reduc-tion	
Low (I)	-1.32	5.4%	-5.48	10.6%	$p < 0.01$
Medium (II)	-5.81	20.9%	-15.76	37.5%	$p < 0.01$
High (III)	-6.96	23.6%	-20.59	38.3%	$p < 0.01$
Difference between immersion	I – II	$p < 0.01$		$p < 0.01$	
	I – III	$p < 0.01$		$p < 0.01$	
	II – III	NS		NS	

Fig. V : Percentage reduction of surface microbhardness in dyract AP and Fuji II L.C.



Discussion:

The role of acid in causing dental erosion, where there is irreversible loss of dental hard tissue by a chemical process without the involvement of micro-organisms has long been established. The acids maybe derived from intrinsic or extrinsic sources. In the oral environment, both dissolution of elements and erosion of the non soluble components of the material occur on exposure to acidic media.

Steffen (1996) reported that it was the chemicals in Cola soft drink that affected the integrity of the enamel surface. Though enamel being the hardest material reported, is not spared of the devastating effects of Cola. It is no matter of surprise when tooth coloured materials with mechanical properties much inferior than enamel, exhibit higher vulnerability to the effects of Cola. The observed surface damage was attributed to softening or removal of portion of the set matrix by chemical in oral environment. Thus, interactions among substances in

oral cavity have a negative impact on the durability of dental restorations (Wu et al, 1984).

The erosive potential of soft drinks has been reported both *in vivo* and *in vitro*. However, many erosion studies have employed extremely long intervals of immersion in acidic solutions (Steffen, 1996; Rugg-Gunn et al, 1998; Sorvari et al, 1994; Meurman et al, 1991; Grando et al, 1996). There are number of possible limitations in above mentioned studies, if we attempt to use them as proxies of a real life situation. Principally these do not accurately depict the actual impact of the frequency, prolonged and continuous exposure to Cola (Maupomé et al, 1998; Steffen, 1996; Watts et al, 1995; Chadwick et al, 1990). Accordingly, a more realistic consumption pattern replicated under experimental conditions would be helpful in determining the actual impact of soft drinks by resembling real exposure. In the present study different immersion regimes were followed (Maupomé, 1998; Maupome et al, 1999).

The results of dye penetration scores were least in low and medium immersion group for Dyract AP and Fuji II L.C restorative materials. While highest dye penetration scores in high immersion group for both Dyract AP and Fuji II L.C restorative materials were observed.

Steffen (1996) stated that the chemical in Cola soft drinks affected the integrity of the enamel surface; his study concluded that Cola removed much of the sealant along with the enamel. It is quite probable that the higher microleakage scores seen in the present study could be due to much of the restorative materials being removed along with the enamel by the high immersion Cola regimes.

Surface deterioration of Dyract AP and Fuji II LC restorative materials were placed in a brass mould which ensured standardization of the shape and size of each circular discs (Kudalkar & Damle, 1997). The setting material were covered with matrix strips on either side to avoid early moisture contamination and were held under constant hand pressure using glass slab on either side in order to obtain polished flattened surface. This polished flattened surface was essential to prevent distorted indentation for hardness measurement on any material (Kelleher & Bishop, 1999; Maupomé et al, 1998; Cattani-Lorente et al, 1999; Attin et al, 1996).

Before subjecting the pellets for cola immersion, base line VHN value for each circular disc

was evaluated using surface microhardness tester (Shimadzu HMV-2000, Germany). Vickers hardness measurements covered the requirements of the standard test method of materials as defined by American society for testing materials (Attin et al, 1996).

The microhardness tester was standardized prior to indentation on each circular disc. The testing parameter of 100 gm of force for 15 seconds initiated no cracks on the surface of the material, thereby, providing a size of indentation that allowed measurement of surface hardness of these material. Similar method was also used by Attin et al (1996); Gladys et al (1997) and Cattani-Lorente et al (1999).

Attin et al (1996) reported that Dyract AP restorative material had higher surface microhardness than did Fuji II LC restorative material. In our study, base line surface microhardness was at par with the values reported by Gladys et al (1997). Bothe the study showed surface microhardness of Fuji II LC has higher VNH than Dyract AP restorative material.

The results of this study showed generalized reduction in surface microhardness in all the three immersion groups of Dyract AP and Fuji II LC restorative materials. de Gee et al (1996) reported that although in Fuji II LC the interpenetrating matrices of cross-linked polyalkanoate and poly-HEMA are not chemically integrated, but merely entangled with one another, the presence of the resin appears to be sufficient to provide protection against an environment with pH of 5.0. They reported that in this category of materials susceptibility to acids becomes noticeable at low pH values (pH 4).

Studies on polyacid modified resin composites by Attin et al (1998) and Watts et al (1995) proved that these materials are surface-softened by an acidic environment. The acidic attack resulted in a loss of structural ions from the glass phase of polyacid modified composites. Watts et al (1995) reported that at pH 6-3, hardness decreased by a factor of 5. The pH of Cola soft drink is pH < 3. Hence, this low pH could have caused generalized reduction of microhardness.

In the low intake group of Dyract AP and Fuji II LC restorative materials, statistically no significant reduction of surface micro-hardness was seen. While in medium and high immersion groups of both the restorative materials showed statistically significant ($p < 0.01$) reduction in microhardness. This could be

probably because of frequent exposures to the acid pH of the Cola.

Statistically significant difference ($p < 0.01$) was seen between Dyract AP and Fuji II LC restorative materials in reduction of microhardness in all the three groups. The VHN of Fuji II LC was higher than those of Dyract AP. But after subjecting to various immersion regimes, the percentage reduction in the VHN values were greater in Fuji II LC given than those observed in Dyract AP group.

The percentage reduction in microhardness is higher in Fuji II LC than Dyract AP probably due to difference in matrix formation. The set cement of Fuji II LC materials have a polyalkenoate network entangled with polymer chain of the HEMA monomer. The higher deterioration of Fuji II LC shows that the coherence of filler particles embedded in the interpenetrating matrices of polyalkenoate and polymers is inferior. This may be caused by the partial replacement of the rigid polyalkenoate network by the flexible polymer chain. A probable reason for a lower difference in base line and final VHN of Dyract when compared to Fuji II LC could be the higher resin component of Dyract (approx. 28%) than Fuji II LC (6%) (Hse et al, 1999; Torstenson et al, 1988). Composite having maximum resin content is not effected by the pH (Chadwick et al, 1990; de Gee et al, 1996).

While comparison of surface microhardness values between low immersion group with medium and high immersion groups showed statistically significant differences, comparison between medium and high immersion showed similar reduction in microhardness. This shows that frequent exposure to these acidic soft drinks may have caused more surface deterioration than low intake.

The present study was a quantitative (surface microhardness and marginal integrity) evaluation and it may not fully reveal the extent of changes occurring. If, combined with qualitative evaluation, it could have revealed the extent of the changes occurring, which could affect the clinical integrity of the material in the oral environment.

Conclusion:

Prolonged exposure to acidic media adversely affected both the marginal integrity and micro hardness of resin modified glass ionomer and compomer. It is clear from the result of this study that the Cola soft drinks affected the marginal integrity and surface

microhardness of the Dyract AP and Fuji II LC restorative materials. This study is important because it points to a dietary insult that is wholly preventable. Thus it can be concluded that the frequency of exposure to Cola is directly proportional to the marginal integrity and surface deterioration of the material studied. Both Dyract AP and Fuji II LC revealed similar dye penetration scores. The two materials also showed reduction in surface microhardness under all the immersion regimes. However, the percentage reduction in surface microhardness was higher for Fuji II LC than Dyract AP.

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