Beverages Immersion Effect on Compomer and Giomer Microhardness

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Abstract

The aim of this study was to evaluate and compare the beverages effect on micro-hardness of compomer and giomer direct restorative materials in comparison with mineral water.

Two types of direct restorative materials of A3 shade were selected for this study: Compomer (Dyract extra Dentsply, Yourk , PA, USA) and Giomer (Beautiful-II, Shofu, San Marcos, CA, USA). Thirty specimens were prepared from each restorative material (total number of specimens were 60). Each specimen was prepared by compressing sufficient amount of material into a mould of 6 mm in diameter and 2 mm in thickness by two glass slides with acetate celluloid strip in between and curing the specimen by making the curing tip in intimate contact with the acetate celluloid strips covering the giomer top surface with LED Woodpacker light curing unit for 20s with an LED of output 600 mW/cm2 while compomer was light cured similarly but for 40s on each surface of the specimen (top and bottom). The thirty specimens of each group were sub divided into three subgroups (n=10) according to the 3 types of beverages being selected in this study. The top and bottom surfaces were divided into two halfs: 1st half was subjected to microhardness testing before immersion, while microhardness testing was performed on the 2nd half after immersion in beverages. pH values were recorded for each beverage solution with pH meter (METTLER TOLEDO, CANADA). Vickers micro hardness testing was performed with microhardness tester (Micro hardness tester FM-800, FUTURE-TECH, Japan) at 300g load and 15 seconds according to ISO 4049 for both top and bottom surfaces by making three indentations and considering the mean microhardness value for each surface to be the Vickers hardness number for that surface. Three types of beverages were used in the study (Cola, coffee and mineral water). Specimens were kept in distilled water for 24 hours before immersing them in any beverage. The specimens were alternately immersed in glass containers containing 25 ml of each media for 2 minutes in three cycles. The same protocol was done for 28 days consecutively. The beverages (immersion solutions) were refreshed daily to maintain the pH level. After the immersion sequence was completed, the compomer and giomer specimens were rinsed in distilled water, blotted dry and subjected to surface microhardness testing.

Data was statistically analysed by calculating the differences between the values before and after immersion of the sixty specimens for their tops and bottoms with one way ANOVA at 5% level of significance.

Statistical analysis of the data revealed that, there was a statistically significant difference between the 6 groups being tested in their differences before and after beverage immersion (ANOVA, $p \leq 0.05$) for their tops while there was a statistically insignificant difference between the 6 groups (ANOVA, $p \geq 0.05$) for their bottoms. The pH values of the immersion solutions were recorded as follows: aerated beverage (Coco-Cola) (2.665); coffee (Nescafé classic 3in1) (5.549); and mineral water (Mai Dubai) (7.2).

In general, immersion in any beverage resulted in reduced microhardness values of both restorative materials tops and bottoms. Water immersion resulted in minimal microhardness differences values for both restorative materials tops and bottoms. Cola immersion resulted in highest microhardness reduction for giomer tops and bottoms while coffee resulted in highest microhardness reduction for compomer tops and bottoms.

Clinical significance: Beverages contain chemical components and their acidic nature or water content might affect the hardness of direct restorative materials that might lead to the degradation at the matrix/filler interface by acid attack and consequently a negative effect on the general performance of the affected restoration in oral service.

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Introduction

People consumption of acidic food, fruit juices, soft drinks, coffee, tea, or wine can result in surface damage and decrease hardness and esthetic qualities of a restorative material.

Degradation in the oral cavity is a complex phenomenon, i.e., related to disintegration and dissolution of restorative materials in the oral cavity.[1] Consumption of acidic food, fruit juices, and soft drinks can result in decrease in microhardness and bad esthetic appearance.[2]

There are different forms of destructive processes leading to irreversible loss of tooth structure other than caries. They can be referred to as abrasion, demastication, abfraction, resorption, and erosion.[3] Acidic soft drink causes demineralization on enamel surface. Maximum consumption of fruits, acidic drinks, and liquid medications may possibly be the etiological and aggravating causes for dental erosion. Extensively used esthetic dental biomaterials available with different properties and colors/shades, used in anterior and posterior restorations, may also be the reason for loss or change in tooth structure. Destruction and disintegration of restorative materials is related to a complex phenomenon of degradation in the oral cavity.[4]

Our study determined the effect of different beverages on the microhardness of commonly used resin-based restorative materials including compomer and giomer. Giomer is a group of direct restorative materials and adhesives that offers aesthetics, handling and physial properties of composite resins with added benefits of high radiopacity, antiplaque effect, fluoride release & recharge.[5]

Compomers are dental products marketed as a hybrid class of direct restorative dental materials in an attempt to combined benefits of composites (the “comp” in their name) and glass ionomers (“omer”). Based on a critical review of the literature, the author argues that “compomers” do not represent a new class of dental materials but are merely a marketing name given to a dental composite.[6]

Materials and methods

Two types of direct restorative materials of A3 shade were selected for this study: Giomer (Beautiful-II, Shofu, San Marcos, CA, USA) and compomer (Dyract extra Dentsply, Yourk , PA, USA). Thirty specimens were prepared from each restorative material (total number of specimens were 60). Each specimen was prepared by compressing sufficient amount of material into a metal mould of 6 mm in diameter and 2 mm in thickness[7] (Figure 1) by two glass slides with acetate celluloid strip in between and curing the specimen by making the curing tip in intimate contact with the acetate celluloid strips covering the giomer top surface with LED Woodpacker light curing unit for 20s with an LED of output 600 mW/cm^2 while compomer was light cured similarly but for 40s on each surface of the specimen (top and bottom).[8] The sixty specimens (30 giomer + 30 compomer) were assigned into six groups (G1-G6) (n=10) as being described in Table 1 according to the type of restorative material and immersion solution. The top and bottom surfaces were divided into two halfs: 1st half was subjected to microhardness testing before immersion, while microhardness testing was performed on the 2nd half after immersion in beverages. Vickers micro hardness testing was performed with microhardness tester (Micro hardness tester FM-800, FUTURE-TECH, Japan) at 300g load and 15 seconds[7] according to ISO 4049 for both top and bottom surfaces by making three indentations and considering the mean microhardness value for each half surface to be the Vickers hardness number (VHN) for that half (top or bottom) (Figure 2). Three types of beverages were used in this study (Cola, coffee and mineral water). The composition of each beverage and mineral water used in this study are shown in Table 2 while the summery of direct restorative materials used in this study (manufacturer’s data) are listed in Table 3.Specimens were kept in distilled water for 24 hours before immersing them in any beverage.

The specimens were alternately immersed in glass containers containing 25 ml of each media for 2 minutes in three cycles.[8]The same protocol was done for 28 days consecutively. The beverages (immersion solutions) were refreshed daily to maintain the pH level. The specimen protocol simulated an individual drinking acidic drinks and caffeine drink. After the immersion sequence was completed, the giomer and compomer specimens were rinsed in distilled water, blotted dry and subjected to surface microhardness testing.[9]

pH values were recorded for each beverage solution with pH meter (METTLER TOLEDO, CANADA) by placing an electrode in 5 ml of test solution, which was calibrated with standard solutions between each measurement for accuracy. Data was statistically analyzed by

calculating the differences between the values before and after immersion of the sixty specimens for their tops and bottoms with one way ANOVA at 5% level of significance.

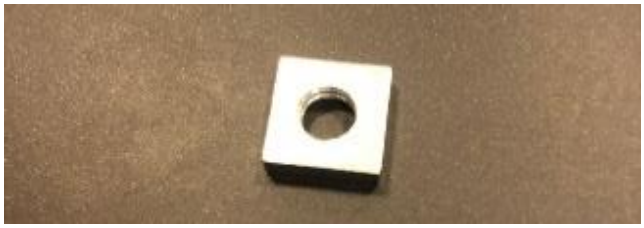

Figure 1. The metal mold of 6 mm in diameter and 2 mm in thickness used in the study.

Figure 2. Surface indentation on specimen surface under magnification of 40X.

Compomer	Group 1	was incubated in cola
	Group 2	was incubated in coffee
	Group 3	was incubated in mineral water
Giomer	Group 4	was incubated in cola
	Group 5	was incubated in coffee
	Group 6	was incubated in mineral water

Table 1. The assignment of compomer and giomer groups in immersion beverages.

Cola (Coca-Cola)	Nescafé 3 in 1	Water (Mai Dubai)
phosphoric acid, water , caramel colours, coca-flavours, carbohydrates 10.6g, total sugars 10.6g, proteins 0.0g, fat/saturated fat 0.0g, sodium less than 10mg, caffeine content 10 mg.	protein 1.5 g, carbohydrates 75g carbohydrates of which sugar 59.4g, fat 12.2 g saturated fat 11.7 g, sodium 0.17 g.	calcium 20mg, magnesium 10 mg, sodium 3.5mg, potassium 5, chloride 50mg, sulphate 20mg, bicarbonate 18.5mg, nitrate 0.2mg, carbonate <1mg, fluoride 0, total hardness 91, total dissolved solids 127.

Table 2. The composition of each beverage immersion solution used in this study (manufacturer's data).

Product	Brand	Manufacturer	Resin Composition	Filler composition
Compomer	Composan Glass	PROMEDICA, Neumünster, Germany	uretgane dimethacrylate difunctional resin monomer	fluro-alumino-silicate glass, barium glass and zirconia/silica
Giomer	Beautiful-II LS	Shofu, San Marcos , CA, USA	Bis-GMA, TEGDMA	Aluminofluoro-biosilicate glass, S-PRG filler

Table 3. Summery of direct restorative materials used in this study (manufacturer's data).

Results

Mean VHN differences (VHN before immersion – VHN after immersion = VHN difference) and standard deviation at the top, bottom of G1-G6 are listed in Table (4). Figures 3&4 represent mean VHN differences at the top, bottom surfaces of compomer and giomer, in the three solutions respectively. Statistical analysis of the data revealed that, there was a statistically significant difference between the 6 groups being tested in their VHN differences before and after beverage immersion (ANOVA, $p \leq 0.05$) (Table 5) for their tops while there was a statistically insignificant difference between the 6 groups (ANOVA, $p \geq 0.05$) (Table 6) for their bottoms. The pH values of the immersion solutions were recorded as follows: aerated beverage (Coco-Cola) (2.665); coffee (Nescafé classic 3 in1) (5.549); and mineral water (Mai Dubai) (7.2).

Solution	Compomer				Giomer			
	T		B		T		B	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cola	7	0.51	4.26	0.44	12.06	0.79	6.21	0.82
Coffee	8.95	0.4	5.24	0.47	10.86	0.97	3.47	0.41
Water	1.05	0.07	0.42	0.03	2.07	0.12	1.95	0.07

Table 4. Mean VHN differences at the top, bottom surfaces of G1-G6.

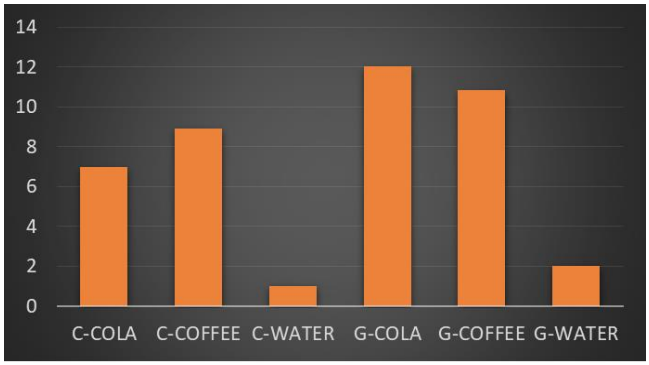

Figure 3. Mean VHN differences of the top surfaces for the six groups.

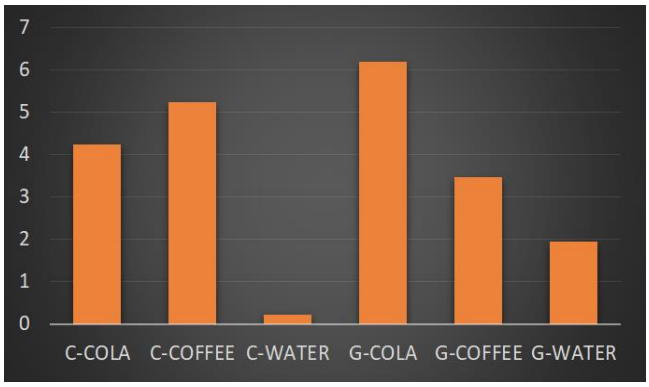

Figure 4. Mean VHN differences of the bottom surfaces for the six groups.

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
C-COLA	10	70	7	26.6333
C-COFFEE	10	89.5	8.95	16.5939
C-WATER	10	10.5	1.05	0.56944
G-COLA	10	120.6	12.06	63.5538
G-COFFEE	10	108.6	10.86	95.6893
G-WATER	10	20.7	2.07	1.54456

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1040.13	5	208.026	6.10094	0.00015	3.37691
Within Groups	1841.26	54	34.0974			
Total	2881.39	59				

Table 5. One way ANOVA of the VHN differences for the six groups (Top surfaces).

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
C-COLA	10	42.6	4.26	20.116
C-COFFEE	10	52.4	5.24	22.52267
C-WATER	10	4.2	0.42	0.097333
G-COLA	10	62.1	6.21	67.421
G-COFFEE	10	34.7	3.47	17.569
G-WATER	10	19.5	1.95	0.596111

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	227.8868	5	45.57737	2.131076	0.075577	3.376912
Within Groups	1154.899	54	21.38702			
Total	1382.786	59				

Table 6. One way ANOVA of the VHN differences for the six groups (Bottom surfaces).

Discussion

Once in the oral cavity, restorative materials are exposed to a variety of adverse conditions including the presence of acidic foods and drinks.[10]

Therefore, in this study we tested the effect of certain beverages on the microhardness of two tooth colored restorative materials Compomer and Giomer.

This was done by immersing the restorative materials in the three solutions and then stored in distilled water for the rest of the day to simulate the washing effect of saliva and represent a lower frequency of intake for a period of 28 days. Distilled water was selected instead of artificial Saliva to simulate the washing effect of saliva because the artificial saliva storage medium is not considered to be a more clinically relevant environment.[11]In addition, Turssi, et al.[12] evaluated the influence of storage media upon the micromorphology of resin-based materials and achieved approximately similar results for distilled water and artificial Saliva.

Our present results revealed that, the two restorative materials showed a significant surface microhardness reduction (tops) after the 28 days storage and immersion period, regardless of the solution used as seen in statistical results (Table 5). However, specimens that were immersed in cola and coffee (Nescafé) demonstrated greater surface microhardness reductions (tops & bottoms) when compared to the specimens stored in water after the evaluation period.

Our present results also demonstrated giomer specimens' top surfaces were affected significantly more than compomer top surfaces in

all the immersion beverages as we can see in Figure 3. Similarly, giomer specimens' bottom surfaces were affected significantly more than the compomer bottom surfaces except for the specimens immersed in coffee as shown in Figure 4.

Solutions compositions (Table 2), apart from softening the resin matrix and decreasing the microhardness of the giomer, they might affect the resin-filler interface of giomer, resulting in debonding of filler matrix. This might be associated with microscopic cracks in the restorative material.[13] Therefore, giomer was significantly affected by immersion in cola more than compomer.

A resin-based restorative material may include different types of inorganic fillers. It has been noted that restorative materials containing "zinc, barium glass, and zirconia/silica fillers were shown to be more susceptible to aqueous attack than those containing quartz fillers. In the present study, the tested compomer contained barium glass and zirconia/silica fillers (manufacturer's data) (Table 3) ; hence, the filler composition of the materials could be a possible reason for the decreased surface microhardness values of the compomer in all of the tested solutions but with the highest amount of reduction in coffee.[14,15]

Previous studies have revealed that compomers release higher amounts of fluoride into acidic buffers than into neutral buffers, indicating that the structure of compomers could have been solved at a low pH.[16]The pH of the coffee (Nescafé) used in our study was 5.549 which could be a possible cause behind higher compomer VHN differences (reduction) after being exposed to coffee immersion than that with giomer.

Both cola and coffee (Nescafé) beverages used in this study, had negative impacts on the microhardness of both compomer and giomer but with different modes of action. As the effect of coffee was mainly due to the presence of water in coffee, and the effect of water uptake can degrade polymer materials. When polymer materials absorb water, coupling agents cause hydrolysis and loss of chemical bond between filler particles and the resin matrix.[17]Filler particles dislodge from the outer surface of the material causing surface roughness and decreased microhardness.[18]Also, the pH of the coffee solution was acidic, and the fact that it contains amino acids and sugars could be the another possible cause.[19] On the other hand, the lowest pH among the beverages in the present study was for Coca-Cola. It has been reported that a low pH in acidic food and drink induces erosive wear in materials.[20] Although Coca-Cola is the lowest titratable acidity, but Coca-Cola is a carbonate beverage containing carbonic acid and phosphoric acid which promotes dissolution and easily eroded the materials.

In our opinion, part of the reduction in the surface microhardness in both types of resin based restorations after storage in water was due to water sorption which causes softening of the materials. The sorbet water not only promotes the acid-base reaction, but also acts as a plasticizer, thereby reducing the strength of the material and possibly may lead to slight swelling of the material leading to reduction in microhardness.[21]

The microhardness values before immersion of the bottom surfaces of giomer and compomer were in general lower than that of the top surfaces due to the fact that curing light is being absorbed and scattered by resin based restoration material thickness, resulting in relatively lower light intensity reaching the bottom surface and this finding agreed with Bayindir and Yildiz[22] whom found that, there was a statistically significant difference between top and bottom surface hardness values, whereby those of the top surfaces were consistently higher than those of the bottom surfaces. The results of this study indicated that, there was a statistically insignificant difference between the 6 groups (ANOVA, $p \geq 0.05$) (Table 6) for their bottoms and this insignificance might be attributed to the relatively more comparable VHN bottom differences values of both compomer and giomer direct restorative materials compared to that of their top differences values (Table 4, Figures 3&4).

After analyzing all these findings we conclude that the first null hypothesis, which stated that "there would be no significant effect of the type of solutions on the surface hardness of the restorative materials", was rejected for the top surfaces and accepted for the bottom surfaces.

Conclusions

Within the limits of this study we can conclude that, in general, immersion in any

beverage including mineral water resulted in reduced microhardness values of both restorative materials tops and bottoms. Water immersion resulted in minimal microhardness differences values for both restorative materials tops and bottoms. Cola immersion resulted in highest microhardness reduction for giomer tops and bottoms while coffee resulted in highest microhardness reduction for compomer tops and bottoms.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

Clinical Significance

Beverages contain chemical components and their acidic nature or water content might affect the hardness of direct restorative materials that might lead to the degradation at the matrix/filler interface by acid attack and consequently a negative effect on the general performance of the affected restoration in oral service.

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