The effect of cyclic immersion in cola drinks on the surface microhardness and surface roughness of different composite filling resin materials

Ali Sa'ad Abu-Naila B.D.S. H.D.D. [(1)]
Dr. Luma M. Baban B.D.S. M.Sc. [(2)]

ABSTRACT

Background: The aim of this study was to evaluate the effect of two types of cola drinks (Regular and Diet) on the surface microhardness and surface roughness of three types of composite resins; Filtek P60 (Packable composite), Tetric-N-Ceram (Nanohybrid composite) and Swisstec (Conventional composite, and to measure the neutralisable acidity of cola drinks.
Materials and methods: Total number of 180 samples are prepared, 60 samples for each type of composite, were divided into two main groups 30 subjected for microhardness test (by Vickers hardness tester) and 30 subjected to surface roughness test (by profilometer). in which composite samples were alternately immersed manually, 5 seconds each, in cola drink and artificial saliva for 10 cycles at room temperature which repeated three times a day (8am,4pm,12am) at 8hours intervals for one week.
Results: Surface microhardness results showed that both types of cola drinks affect the Filtek P60 (packable) composite resin significantly while their effect was with high significant difference for Swisstec (conventional) composite and Tetric-n-Ceram (nanohybrid) composite resin, so the influence of cola drinks was material dependent. Surface roughness results showed that Filtek P60 (packable) composite resin non significantly affected by regular Pepsi and significantly in diet Pepsi, while Tetric-n-Ceram (nanohybrid) composite and Swisstec (conventional) composite showed a high significant difference in both cola drinks, so the influence of cola drinks was material dependent. All types of composites tested in this study showed reduction in VHN values and increasing in means of Ra values after 7 days of immersion in artificial saliva, but the effect was a non significant.
Conclusions: Both cola drinks showed reduction in means VHN values and increasing in means Ra values for all types of composites for all groups. Regular Pepsi is less in their erosive potential and need lesser amount of NaOH to reach the neutrality than diet Pepsi.
Keywords: Pepsi cola, composite, microhardness, roughness. (J Bagh Coll Dentistry 2010;22(2):7-11).

الخلاصة

الغرض من هذه الدراسة المختبرية هو لبيان تأثير نوعين من مشروبات الكولا (المنتظم والخالي من السكر) على الصلادة المجهرية والخشونة السطحية على ثلاثة انواع من حشوات الراتنج المركب وهي من نوع فلتيك ب ٦٠ (مركب متراص)،وتتريك-ن-سيرام (نانوهايبرد)، وسويستيك (مركب تقليدي)، حيث تغمر عينات حشوات الكومبوزت بصورة متوالية وبشكل يدوي لمدة خمس ثواني في مشروب الكولا ثم خمس ثواني في اللعاب الصناعي لمدة عشر مرات في درجة حرارة الغرفة وتكرر هذه العملية ثلاثة مرات في اليوم(٨صباحا،٤مساءا،١٢صباحا) ولأسبوع واحد.

تم تحضير١٨٠) عينة، ٦٠) لكل نوع من انواع الراتنج، والتي قسمت الى ٣٠)عينة لغرض فحص الصلادة المجهرية بواسطة جهاز فكرز لقياس الصلادة و ٣٠) عينة لغرض فحص الخشونة السطحية بواسطة جهاز البروفيلوميتر. لكل نوع من انواع مادة الراتنج قسمت ال ٣٠) عينة كلآتي: المجموعة الاولى: عشْرة عيناتِ غطست في البيبسي كولا المنتظم, المجموعة الثانية: عشْرة عيناتِ غطست في شرابِ البيبسي كولا القليل السكّر المجموعة الثالثة: عشْرة عيناتِ غطست في اللعابِ الإصطناعي

بينت ألنتائج أن مشروبات الكولا أظهرت نقصان في قيم معدلات الصلادة المجهرية وزيادة في قيم معدلات الخشونة لكل المجاميع لكل انواع الراتنج المركب. الراتنج المركب فلتيك ب ٦٠ مركب متراص) ملك اعلى قيمة للصلادة المجهرية متبوعا بسويستيك (مركب تقليدي) ثم تتريك-ن-سيرام (نانوهايبرد) بصورة متوالية .مشروبات الكولا اثرت على الصلادة المجهرية للراتنج المركب فلتيك ب ٦٠ (مركب متراص) بفارق احصائي بينما كان التأثير ذا فارق احصائي عالي لكل من المركب سويستك و المركب تتريك-ن-سيرام،لذا تأثير مشروبات الكولا كان ذا تابعا ماديا. مشروب البيبسي الكولا الخالي من السكرأظهر نقصان في قيم معدلات الصلادة المجهرية وزيادة في قيم معدلات الخشونة لكل المجاميع لكل انواع الراتنج المركب اكثر من مشروب البيبسي كولا المنتظم. قياس معادلة الحموضة لمشروبات الكولا كشف ان البيبسي المنتظم يحتاج الى كمية اقل من (هيدروكسيد الصوديوم) للوصول الى الحياد من البيبسي الخالي من السكر بالرغم من ان حموضة البيبسي المنتظم اكثر من البيبسي الخالي من السكر.مقاييس الخشونة السطحية اظهرت انها كانت عند المركب تتريك-ن-سيرام (نانوهايبرد) الأوطأ متبوعة بالمركب فلتيك ب ٦٠ والمركب سويستك على التوالي. نتائج الخشونة أظهرت أن مشروبات الكولا اثرت على المركب فلتيك ب ٦٠ بفرقة غير هام احصائيا في البيبسي المنتظم مع فرق هام في البيبسي الخالي من السكر، بينما المركب تتريك-ن-سيرام والمركب سويستك اظهرا فرقا عالي الاهمية في كلتا مشروبات الكولا، لذا تأثير مشروبات الكولا كان ذا تابعا ماديا. كل انواع المركبات المفحوصة في هذه الدراسة أظهرت أظهرت نقصان في قيم الصلادة المجهرية وزيادة في الخشونة بعد ٧ ايام من الغمر في اللعاب الإصطناعي،لكن التأثيركان ذا فارق احصائي غيرمهم.

INTRODUCTION

Composite resins are widely used in restorative and pediatric dentistry. Most of the available composites contain a polymer matrix of dimethacrylate monomers, such as Bis-GMA, UDMA, and TEGDMA, inorganic filler particles coated with a methyl methacrylate functional silane coupling agent to bond the filler to the organic matrix, and a photoinitiator system to allow photoactivation by light units [(1)].

The physical and mechanical properties of composite resins are indicators that predict the behavior of composite restorations, other aspects, such as material biodegradation, must be taken into account in the clinical performance of this type of restorative procedure. The critical oral environment conditions, i.e., pH changes and

(1) MSc student, dep. of conservative dentistry, college of dentistry, university of Baghdad.
(2) Professor, dep. of conservative dentistry, college of dentistry, university of Baghdad.

humidity, may increase resin composite biodegradation over time [(2)]. This phenomenon is a complex process that may lead the composite polymer matrix to collapse, causing several problems such as filler-polymer matrix debonding [(3)] Acid erosion has clinical significance, because acidic conditions can be occurred orally either due to the ingestion of acidic foods or the degradation of polysaccharides to acids in stagnant areas of the mouth [(4)].

Cola drinks suppose to cause the surface degradation of resin matrix and surface erosion of filler contents. In addition, the surface degradation of resin materials is related to the content of the fillers, distribution of the fillers, composition of the matrix resin, and the effect of silane surface treatment on the fillers [(5)]. The increasing demand for esthetic dentistry has been coupled with a rapid development of new restorative materials. Packable resin and nanohybrid composite is one of the newly developed esthetic restorative materials, and it is currently being used for dental clinical work as well as in operative dentistry. However, in the complex environment of the oral cavity (with exposure to alcohol, acids, and mechanical abrasion and temperature changes), packable resins and nanohybrid composite are expected to undergo considerable degradation. However in oral environment, saliva modifies the erosive process and erosive intensity is modified by quality and quantity of saliva. Diminished salivary flow was susceptible to erosive tooth damage [(6)].

So this in vitro study was designed to simulate the washing effect of saliva with individual drinking of cola soft drink by cyclic specimen immersion, and to evaluate the influence of cola drinks on the surface degradation of composite resin by measuring the surface microhardness and roughness.

MATERIALS AND METHODS

Total numbers of 180 samples were prepared, 60 samples for each type of composite which are (Filtek P60 (packable), Swisstec (conventional) and Tetric-n-Ceram (nanohybrid) composite resins, which were divided into two main groups 30 samples were subjected for microhardness test (by Vickers hardness tester) and 30 samples were subjected to surface roughness test (by profilometer).

For each types of composite group the 30 samples were subdivided as follows:-

Group 1: Ten samples were immersed in regular Pepsi cola.

Group 2: Ten samples were immersed in diet Pepsi cola drink.

Group 3: Ten samples were immersed in artificial saliva.

By utilizing cylindrical Teflon molds (2mm in height & 8mm in diameter).The molds were placed on a transparent celluloid strip that fixed on a glass cement slab. The materials were inserted and pressed into the mold until it were intentionally overfilled. Then the materials were covered with another matrix strip and a glass microscopic slide.100 gm pressure was applied to expel excess material from the mold. Each specimen were light-cured through the application of the tip of light cure directly on the top glass slide (distance about 1.2mm, which is the thickness of the glass slide and celluloid strip), all samples were stored in plastic containers that contained distilled water in an incubator at 37 ^{o}C for 24 hours before they were tested [(7)]. The artificial saliva prepared manually with the assistance of a specialized chemist and it's composed of 2.2g/L gastric mucin, 0.381g/L sodium chloride,0.738g/L potassium phosphate, 1.114g/L potassium chloride, 0.02% sodium azide, trace of sodium hydroxide to reach (pH 7.0) [(7)].

The acidity of regular and diet Pepsi cola was measured with a PH meter (model 3320) .The pH meter was calibrated using test solutions of known pH (Fisher Scientific International, Loughborough, UK) before testing the drinks. The neutralisable acidity of each drink was tested by placing 20 mls of the drink in a glass beaker placed in a thermostatically controlled water bath held at 37°C. 0.1M sodium hydroxide solution was gradually added to the drink sample and the pH rise was continuously monitored until the pH increased to neutrality. Each sample was stirred continuously as the solution of sodium hydroxide was added. The volume of sodium hydroxide required to increase the pH of the sample to neutrality was noted; this was repeated five times for each drink. [(8)]. All composite samples undergo baseline measurements for surface roughness and surface microhardness before immersion in cola drink.

After baseline measurement the composite samples were alternately immersed manually, 5 seconds each, in cola drink and artificial saliva for 10 cycles at room temperature which repeated three times a day (8 am, 4 pm, 12 am) at 8 hours intervals for one week. Because during consumption, the drinks contact only shortly with the tooth surface before it's washed away by saliva. In previous studies drinks usually contacted the tooth surface for a prolonged period of time or did not account for the role of saliva. The specimen soaking protocol was simulated from an individual drinking a can of Pepsi cola (330ml) and the total soaking time was 100 seconds. After the soaking sequence was completed the specimen was rinsed with distilled water and restored in artificial saliva which discarded after each soaking sequence [7].

The microhardness measurement were performed using Vickers hardness by using micromet microhardness tester (micro indentation test).In which a 100g load were applied for 15 seconds[14] in which three indentations were made for each sample and converted into VHN. The indentation were positioned to cover most of the specimen surface by equal placement over a half circle which result in wider spaced indentation and not closer than 1mm to the adjacent ones or to the margin of the specimen, the average of three measurements were calculated and obtained as one reading. The roughness of the surface "Ra value" is the arithmetic mean at all values of the roughness profile within the measuring length [10]. Each sample were measured using traveling length of 8mm and each sample were measured three times in various locations within the area of experimental zone, the Ra value of each sample were the average of these measurements. The horizontal magnification that used in this study is 1000x; while in vertical magnification is 500 xs.

RESULTS

Statistical analysis of data by using ANOVA test for all types of composites for all groups revealed that there is a non significant difference ($P>0.05$) in VHN values for Filtek P60 (packable) composite when all its groups compare with each other, while there is high significant difference ($P<0.001$) in VHN values between the groups for both Swisstec (conventional) composite and Tetric-n-Ceram (nanohybrid) composite which is shown in table 1.

Percentage of microhardness reduction for all the groups of all types of composites was measured by using the equation [(After/Before×100)-100]. The data revealed that the lowest reduction in microhardness was in the saliva group of

Filtek P60 (packable) composite, while the highest reduction in microhardness was in the diet Pepsi group of Tetric-n-Ceram (nanohybrid) composite, which is shown in table 2.

Statistical analysis of data by using ANOVA test for all types of composites for all groups revealed that there is a non significant difference ($P>0.05$) in (Ra) values for Filtek P60 (packable) composite when all its groups compare with each other, while there is high significant difference ($P<0.001$) in (Ra) values between the groups for both Swisstec (conventional) composite and Tetric-n-Ceram

The percentage of roughness increasing for all the groups of all types of composites was measured by using the equation [(After/Before×100)-100]. The data revealed that the lowest increasing in roughness was in the saliva group of Filtek P60 (packable) composite, while the highest increasing in roughness was in the diet Pepsi group of Tetric-n-Ceram (nanohybrid) composite, which is shown in table 4.

The results revealed that regular Pepsi need lesser amount of NaOH to reach the neutrality than diet Pepsi in spite of the acidity of regular Pepsi is more than diet Pepsi, which is shown in table 5.

DISCUSSION

Most restorative resin materials are expected to demonstrate partial surface alterations upon immersion in an aqueous environment, in our present study the Filtek P60 (packable) composite resin VHN values showed a significant reduction in VHN values after immersion in regular and diet Pepsi cola drinks, while the Swisstec (conventional) composite and Tetric-n-Ceram (nanohybrid) composite showed a high significant reduction in VHN values after immersion in regular and diet Pepsi cola drinks. Surface roughness revealed that Filtek P60 (packable) composite resin Ra values showed a significant increasing after immersion in diet Pepsi cola drinks, and a non significant increasing in Ra values after immersion in regular Pepsi cola, while the Swisstec (conventional) composite showed a significant increasing in Ra values after immersion in regular Pepsi cola and a high significant increasing in Ra values after immersion in diet Pepsi cola, and for Tetric-n-Ceram (nanohybrid) composite showed a high significant increasing in Ra values after immersion in regular and diet Pepsi cola drinks.

These results may be attributed to (1) the volume and size of composite filler particles (2)Another explanation to this reduction in VHN values and the increasing in Ra values may be attributed to the water absorption and hydrolytic degradation of the filler surface caused by filler/matrix cracking. Bis-GMA copolymer is highly susceptible to chemical softening, with a broad increasing range of solubility parameters. The extent of softening of Bis-GMA copolymer depended on the soaking chemicals, the incorporation of TEGDMA in Tetric-n-Ceram (nanohybrid) composite resulted in an increase in water uptake in Bis-GMA. Hydrophilic groups such as the ethoxy group in TEGDMA are thought to show affinity with water molecule by hydrogen bonding to oxygen [11].

(3) Microhardness and surface roughness are not related exclusively to the particle content in the composite resin composition and the distribution of the filler sizes may be more important factors for this property, so surface degradation may be happened when the filler and the matrix resin were too weakly bonded, this might be attributed to insufficient surface treatment with silane was thought to result in filler erosion and it has been suggested that silanization of filler particles plays an important role as does the type of the resin used in the resin based composites [12]. All types of composites tested in this study showed a non significant reduction in VHN values and the increasing in Ra values after immersion in artificial saliva, which could be attributed to water can infiltrate and decrease the mechanical properties of the polymer matrix, by swelling and reducing the frictional forces between the polymer chains, similar results were obtained with artificial saliva solutions. Composite resins generally contain more organic matrix and thus may be more susceptible to water absorption and subsequent surface disintegration in an aqueous environment [13].

Table 1: ANOVA test between the groups of each type of composite

Variables		Mean	S.D.	ANOVA test d.f.=29 F-test	ANOVA test d.f.=29 p-value
Packable composite	Baseline	84.19	1.6	2	0.126 N.S.
	Pepsi	83.53	1.7		
	Pepsi diet	82.51	1.63		
	Saliva	84.18	1.9		
Conventional composite	Baseline	54.95	1.6	8.65	0.000 H.S
	Pepsi	53.3	1.44		
	Pepsi diet	51.83	1.33		
	Saliva	54.83	1.75		
Nano-hybrid composite	Baseline	56.02	1.57	21.2	0.000 H.S
	Pepsi	53.01	1.65		
	Pepsi diet	51.58	1.08		
	Saliva	55.88	1.61		

Table 2: The percentage of microhardness reduction

Variables		Before	After	% Microhardness
Packable composite	Pepsi	84.21	83.53	0.8
	Pepsi diet	84.14	82.51	1.93
	Saliva	84.22	84.18	0.04
Conventional composite	Pepsi	55.04	53.3	3.16
	Pepsi diet	54.96	51.83	5.4
	Saliva	54.87	54.83	0.073
Nano-hybrid composite	Pepsi	56.03	53.01	5.4
	Pepsi diet	56.08	51.58	8.02
	Saliva	55.96	55.88	0.14

This effect may become obvious and with significant reduction in VHN values and the increasing in Ra values if the immersion time in artificial saliva become more than one week which was the period of immersion in our study.A more interesting observation in this study was that the regular Pepsi showed the lesser decrease in VHN values and increasing in Ra values than diet Pepsi for all types of composite resin material.

The surface properties of a composite resin material, especially microhardness and roughness may be greatly affected by the general chemical composition of the beverages, the type of acid present in their formulation, and also the potency of the individual acidic ingredients.

Table 3: ANOVA test between the groups of each type of composite

Variables		Mean	S.D.	ANOVA test d.f.=29 F-test	ANOVA test d.f.=29 p-value
Packable composite	Baseline	0.04	0.005	1.78	0.17 (N.S)
	Pepsi	0.042	0.004		
	Pepsi diet	0.05	0.005		
	Saliva	0.04	0.0077		
Conventional composite	Baseline	0.051	0.005	45.02	0.000 (H.S.)
	Pepsi	0.062	0.005		
	Pepsi diet	0.074	0.004		
	Saliva	0.055	0.004		
Nano-hybrid composite	Baseline	0.03	0.005	49.43	0.000 (H.S.)
	Pepsi	0.05	0.006		
	Pepsi diet	0.06	0.005		
	Saliva	0.035	0.008		

Table 4: The percentage of roughness increasing

Variables		Before	After	% Roughness
Packable composite	Pepsi	0.040	0.042	5
	Pepsi diet	0.04	0.05	25
	Saliva	0.04	0.04	0
Conventional composite	Pepsi	0.051	0.062	21.56
	Pepsi diet	0.052	0.074	42.3
	Saliva	0.053	0.055	3.77
Nano-hybrid composite	Pepsi	0.03	0.05	66.66
	Pepsi diet	0.03	0.06	100
	Saliva	0.031	0.035	12.9

Table 5: The Neutralizable acidity of Pepsi cola drink

Groups	pH		Neutralizable acidity (ml of 0.1 M NaOH)	
	Mean	S.D.	Mean	S.D.
Regular Pepsi	2.48	0.06	8.2	0.7
Diet Pepsi	3.2	0.05	12.4	0.8

In the present study, the larger decrease as observed in microhardness of the composite resin specimens immersed in Diet Cola, in comparison with Regular Cola, could be explained by the possible synergistic softening effect on Bis-GMA copolymer by the inorganic "phosphoric" acid and the organic "citric" acid present in Diet Cola's formulation.

The organic "citric" acid present in diet Pepsi cola in high concentrations could have a more aggressive softening effect than the inorganic "phosphoric" acid present in Regular Cola. Although the regular Pepsi cola is more acidic and it's pH is lower than diet Pepsi cola but the diet Pepsi cola needed more of alkali (base) to be added to it to bring it up to a neutral (pH). So according to the above results the buffering capacity and titratable acidity represents the amount of available acid and is an indication of strength and thus of erosive potential [14].

REFRENCES

1. Sideridou I, Tserki V, Papanastasiou G Effect of chemical structure on degree of conversion in light-cured dimethacrylate-based dental resins. Biomaterials 2002, 23:1819-29.
2. Ana Carolina Valinot, Beatriz Goncalves Neves, Eduardo Moreira da Silva, Lucianne Cople Maia Surface degradation of composite resin by acidic medicines and ph-cycling. J Appl Oral Sci 2008;16:1-11.
3. Soderholm KJ, Mukherjee R, Longmate J. Filler leachability of composites stored in distilled water or artificial saliva. J Dent Res1996; 75: 1692-9.
4. Linlin HAN,Akira OKAMOTO, Masayoshi FUKUSHIMA and Takashi OKIJI. Evaluation of Flowable Resin Composite Surface Eroded by Acidic and Alchoholic Drinks. Dent Materials J 2008; 27(3): 455-65.
5. Lee SY, Greener EH, Mueller HJ, Chiu CH. Effect of food and oral simulating fluids on dentine bond and composite strength. J Dent 1994; 22: 352-9.
6. Cogulu, D., E. Sabah, N. Kutukuler and F. Ozkinag. Evaluation of the relationship between caries and salivary secretary IgA, salivary pH, buffering capacity and flow rate in children with Down's syndrome. Arch Oral Biol 2006; 51 (3): 177-80.
7. Wongkhantee S, Patanapiradej V, Maneenut C,Tantbirojn D. Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent 2006; 34: 214-20.
8. Cornelius Tokunbo Bamise and Olasehinde Fadekemi Bamise Quantifying the Acidic Content of Commercial Yoghurt Drinks in Nigeria Internet. J of Dental Sc 2008; 6:1-13.
9. Juliane Cristina CICCONE-NOGUEIRA1, Mariana Cristina BORSATTO2, Wanessa Christine de SOUZA-ZARONI. Microhardness at different depth varying the post irradiation time, 2007; 15(4): 305-9.
10. Roberson TM, Heymann HO, Swift EJ. Sturdevant`s art and science of operative dentistry. 4ed. London: Mosby Inc 2002; Ch 4: P 191 – 207; Ch 6: P 252–8; Ch 11: P 276–7.
11. Fulya Toksoy Topcu, Gunes Sahinkesen, Kivanc Yamanel, Ugur Erdemir, Elif Aybala, Seyda Ersahan.: Influence of different drinks on the colour stability of dental resin composite. Europ J of Dent 2009; 3: 50-6.
12. Kim KH, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002; 87(6):642-9.
13. Rafael Ratto de Moraes, José Laurindo Machado Marimon, Luis Felipe Jochims Schneider, Mário Alexandre Coelho Sinhoreti , Lourenço Correr-Sobrinho, MS, Márcia Bueno. Effects of 6 Months of Aging in Water on Hardness and Surface Roughness of Two Microhybrid Dental Composites. J of Prosthodontics 2008; 17:4: 323-6.
14. Nuran YANIKOGLU, Zeynep Yesil DUYMUS and Baykal YILMAZ. Effect of different solutions on the surface hardness of composite resin materials. Dent Materials J 2009; 28(3): 344-9.