Effect of Mouth Rinses on Surface Roughness of Two Methacrylate-Based and Siloraine-Based Composite Resins

Ala'a Jawad Kadhim, B.D.S., M.Sc. [(1)]

ABSTRACT

Background: Various fluids in the oral environment can affect the surface roughness of resin composites. This in vitro study was conducted to determine the influence of the mouth rinses on surface roughness of two methacrylate-based resin (nanofilled and packable composite) and siloraine-based resin composites.

Materials and methods: Disc-shaped specimens (12 mm in diameter and 2mm in height) were prepared from three types of composite resin materials: Filtek™ Z350 XT, Filtek™ P60 and Filtek™ P90.Thirty specimens were prepared from each composite type and subdivided into three subgroups (n=10) according to the type of treatment solution: distilled water (control), Listerine (alcohol-containing), Sensodyne Pronamel (alcohol free fluoride- containing).Each subgroup was immersed in 20 ml of treatment solutions and incubated at 37°C for 24 hr and then subjected to surface roughness test by profilometer .The resulting data were statistically analyzed using ANOVA and LSD test at0.05 significance level.

Results: The results of this study showed that both mouth rinses irrespective of the presence or absence of alcohol resulted in significant increase in the surface roughness of the tested resin composite materials compared to control with no significant difference between the two mouth rinses. Comparison among the three types of resin in each treatment solution showed that there was a statistically high significant difference in surface roughness between all subgroups

Conclusion: Both alcohol-containing and alcohol-free fluoride containing mouth rinses cause highly significant increase in surface roughness of composite resins. Composite changes depended on the material itself rather than the mouth rinse solution used.

Key words: Composite resin, mouth rinses, siloraine, surfaces roughness. (J Bagh Coll Dentistry 2016; 28(3):1-7).

INTRODUCTION

One of the factors that determine the clinical longevity of a restoration is its surface characteristics, the restoration must provide a smooth and regular surface, but it is not always possible [(1)].As the composite resins are polymer-based materials, they may undergo degradation inside the oral environment, resulting in alterations of the mechanical properties [(2)].Mechanical properties of composites are not only influenced by their chemical composition but also by the environment to which they are exposed [(3)].

During the last decades, the increasing demand for esthetic dentistry have led to the development of resin composite materials for direct restorations with improved physical and mechanical properties, and clinically acceptable surface smoothness [(4)]. To achieve the last goal, manufacturers predominantly have increased the filler load and reduced the diameter of the filler particles to produce composites with a good mix of polishability and strength [(5)]. Packable composites were expected to exhibit excellent mechanical and physical properties owing to their high filler load [(6)].

Where Nanofill composites consist of individual nanosilica particles and nanoclusters, the nanocluster fillers are agglomerates of nano-sized particles and act as a single unit to achieve higher filler loading and strength [(7)]

However, the shrinkage of the methacrylate resin has remained a major challenge [(8)]. Different high-molecular weight matrix resin compositions have been developed with the aim of diminishing polymerization shrinkage. These include a cationic ring-opening hybrid monomer system that contains siloxane and oxirane structural moieties, this material commonly called siloranes [(9)].

The surface roughness property of any material is the result of an interaction of multiple factors. Some of them are intrinsic that are related to the material itself, such as the filler (type, shape, size and distribution of the particles), the type of resinous matrix as well as the ultimate degree of cure reached, and the efficiency at the filler/matrix interface. Other factors are extrinsic that related to the type of polishing system used, drinks, foods and influence of the oral environments [(10)].

Mouth rinses are considered one of these affecting factors. Mouth rinses are widely used to prevent and control caries and periodontal diseases, and are frequently used, even without professional prescription. These mouth rinses consists of water, antimicrobial agents, salts, and,

(1) Lecturer, Department of Conservative Dentistry, College of Dentistry, University of Baghdad.

in some cases, alcohol [11]. The variation in the concentration of these substances may increase sorption, solubility and surface degradation of resin composites [12].

Taking in consideration the importance of roughness with respect to esthetic and function of restorations, this in vitro study was conducted to analyze the effects of two types of mouth rinses (alcohol-containing and alcohol free fluoride-containing) on the surface roughness of three esthetic restorative materials (nanofilledFiltek Z350, packable Filtek P60 and silorineFiltekP90).

MATERIALS AND METHODS

Specimens'preparation

Ninety specimens (shade A3) were constructed from three composite materials (30 from each). The three resin-based composite materials used in this study are shown in (Table 1). A specially designed cylindrical plastic mold (12mm diameter and 2mm height) was used to prepare disc-shaped composite specimens [13].

A celluloid strip (Odus, Produits Dentaires SA CH-1800 Vevey/Switzerland)was placed on a flat glass slide (Microglass industries, pahari Dhiraj, Delhi) on top of a white background, the mold was then placed on it and slightly overfilled in one increment with one of the composite materials and a second celluloid strip was then placed on top of the mold and overlaid with another glass slide with the application of 200gm load for 1 minute to extrude excess material and obtain a smooth surface[14].

The top slide was then removed and the composite was light cured using a light emitted diode LED curing light (LATTE YDL, China) with a light intensity 1000 m W/cm2, for 20 seconds of exposure time to top and bottom surfaces, respectively following the manufacturer's instructions . The tip of curing light was placed as close as possible to the glass slide to achieve maximum curing depth.

Then all prepared samples were stored in distilled water at 37ºC for 24 hours using incubator, for rehydration and completion of the polymerization to mimic the first day of service in the oral environment[15].

Specimens' Grouping

The specimens of each type of composite were randomly divided into three groups of ten specimens each as follows: Group I distilled water (control), Group II Listerine (alcohol-containing), Group III Sensodyne Pronamel (alcohol free fluoride-containing), The specimens were then immersed in 20 ml of respective treatment solution (Table 2) and kept in an incubator at 37°C for 24 hours that was reported to be equivalent in time to 1 year of 4min daily use [16]. All specimens were removed after 24 hours of their immersion in treatment solution and incubation. Then 20 ml of distilled water (pH=7.53) was used to thoroughly rinse each specimens for 120s. Each specimen was then blotted dry using a filter paper [17]

The pH of treatment solution was recorded before and after immersion using a digital pH meter (Microprocessor PH meter, HANNA PH 213, Italy). For each solution three readouts were taken and the mean PH values were: distilled water-PH: 7.31; Listerine-pH: 4.22; Synsodine Pronamel-pH: 6.21.

Surface Roughness Measurements

The specimens were then checked for post immersion surface roughness. The average values of surface roughness (Ra-µ m) of all specimens were measured by means of a profilometer (Hand-Held Roughness Tester, TR200, Time Group Inc. China).

The profilometer measured each specimen at three areas in various locations with a maximum travelling distance of 11 mm (0.5mm left from both periphery of the specimen). The average value was recorded as the mean Ra of that specimen. The mean Ra values were automatically calculated by the profilometer.

Statistical Analyses

All statistical analyses were carried out using SPSS statistical software (version19.0, SPSS, Chicago, IL, USA). After data collection, mean values and standard deviations were calculated for all groups and subgroups. One way analysis of variance (ANOVA) test was performed among the experimental groups to determine where there any statically significant differences under various conditions.

When a significant difference was found, least significant difference (LSD) test was done to find where the significance occurs. The mean difference is significant at the 0.05 level.

RESULTS

The descriptive statistics (mean and standard deviation) of surface roughness (Ra value in µm) of the different subgroups of Filtek™ Z350 XT, Filtek™ P60 and Filtek™ P90 composite resin materials and the comparison of significance of the different subgroups of each composite resin material byOne-way ANOVA test are presented in Table 3.From this table, it can be seen that the mean Ra values of all subgroups of Filtek™ Z350 XT composite resin material were higher than the mean Ra values of their corresponding subgroups of Filtek™ P60 and Filtek™ P90 composite resin materials. Also we can see that the mean Ra values of Filtek™ P60 is similar to the mean Ra values of Filtek™ P90 in distilled water but they differ after conditioning with the mouth rinses ,since the mean Ra values of Filtek ™ P90 is higher than of Filtek™ P60.

Statistical analysis of data by using the analysis of variance "ANOVA" among the three treatment solution against each type of composite materials revealed that there was a highly significant difference among the three treatment solution in all types of composites used (control, Listerine, and Synsodine Pronamel) $P<0.05$

Further investigation using **LSD**(least Significant Difference)test showed that there was a statistically high significant difference in surface roughness between the subgroups stored in both mouth rinses as compared with control subgroup(P=000), while there was statistically no differences between the subgroups stored in mouth rinses (Listerine and Synsodyne pronamel)($p>0.05$) as shown in Table 4.

ANOVA test was also done among the three tested composite materials against each treatment solution (table 5), it show that there is a highly significant differences among the three composite types in each treatment solution.

Further investigation using **LSD** (least Significant Difference) test was done to find where the significance occur (table 6)showed that there was a statistically high significant differences in surface roughness between all subgroups except for subgroup of P60 and subgroup of P90 in distilled water.

Table 1: Types of composite resin materials used in this study

Product	Composite Type	Resin components	Filler type	Particle size	Filler loading Wt(vol)	Manufacturer
Filtek Z350	Nanofilled	Bis-GMA, UDMA, TEGDMA and Bis-EMA ,PEGDMA	Non-agglomerated /non aggregated silica filler Non-agglomerated /non aggregated Zirconia filler aggregated zirconia/silica cluster filler	20nm silica filler 4-11nm zirconia filler 0.6-10 µm	78.5% (63.3%)	3MDental Product (USA)
Filtek P60	Packable	Bis- GMA,UDMA and Bis-EMA	Zirconia/silica	0.01-3.5 µm (mean0.6 µm)	83% (61%)	3MDental product(USA)
Filtek P90	Micro-hybrid	Silorane (or) ;3,4 Epoxycyclohexyl Ethylcyclopolymethyl siloxane, bis-3,4 Epoxycyclohexy-lethylphenylmethylsilan	Quartz, yttriumfluorid	0.1-o.2µm (mean 0.47µm)	76% (55%)	3MDental Product (USA)

Table 2: Types of mouth rinses used in study

Treatment solutions	Composition	Manufacturer/ Batch number
Listerine	Eucalyptol 0.092%, menthol 0.042%, Menthyl Salicylate 0.06, Thymol 0.064, Water, Alcohol (Ethanol) (21.6%), Sorbitol, Flavoring ,Poloxamer 407,Benzoic Acid sodium saccharin, sodium benzoate, Dand C yellow no. 10, FDand C green no. 3	Johnson and Johnson Healthcare Products, USA3481LZ
Sensodyne Pronamel	water, Glycerin, Sorbitol, Poloxamer 338, PEG-60 Hydrogenated Castor Oil, VP/VA Copolymer, Potassium Nitrate, Sodium Benzoate,Cellulose Gum, Aroma, Sodium xsazd, Propylparaben, Cetylpyridinium Chloride, Sodium Saccharin, Xanthan Gum, Disodium Phosphate, Sodium Phosphate, CI 42090, Contains Sodium Fluoride (450 ppm Fluoride).	GlaxoSmithkline Germany 1188026

Table 3: Descriptive statistics of surface roughness values in µm for all groupsand statistical analysis of data by (ANOVA) among the three treatment solution against each type of composite

Materials		Distilled water	Listerine	Synsodyne pronamel	F-test	Significance
Filtek™ Z350 XT	Mean (µm)	0.0071	0.011	0.012	53.894	0.000 (HS)
	SD	0.00122	0.000816	0.001563		
Filtek™ P60	Mean (µm)	0.00112	0.0073	0.00759	140.949	0.000 (HS)
	SD	0.000123	0.001567	0.00061		
Filtek™ P90	Mean (µm)	0.0012	0.0092	0.0097	513.000	0.000 (HS)
	SD	0.000231	0.000919	0.000949		

Table 4: LSD test between subgroups of the tested solution against each type of composite

Materials	Control and listerine	Control and pronamel	Listerine and pronamel
Filtek™ Z350 XT	0.000(HS)	0.000(HS)	1.000(NS)
Filtek™ P60	0.000(HS)	0.000(HS)	0.511(NS)
Filtek™ P90	0.000(HS)	0.000(HS)	0.154(NS)

Table 5:ANOVAand LSDtests among the three tested material against each treatment solution

	F-value	Significance	Z350 and P60	Z350 and P90	P60and P90
Distilled water	226.595	0.000(HS)	0.000(HS)	0.000(HS)	0.806(NS)
Listerine	25.891	0.000(HS)	0.000(HS)	0.002(HS)	0.001(HS)
SynsodinePronamel	39.271	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)

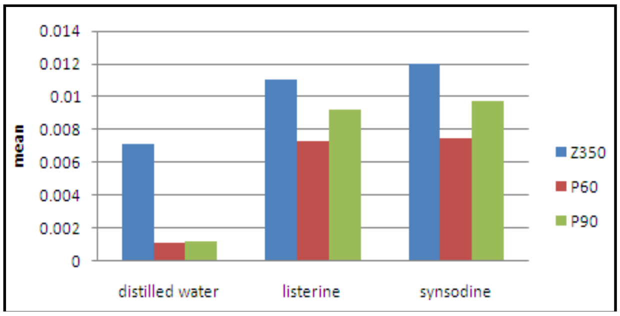

Fig. 1: Mean surface roughness values of all groups

DISCUSSION

The maintenance of a smooth surface is fundamental for improving the clinical longevity of aesthetic materials, whereas rough restorations can lead to periodontal problems or plaque retention, subsequent recurrent decay, surface staining and patient discomfort [(18)]. Bollen et al. (1997) related that some studies suggested a threshold surface roughness for bacterial retention (Ra = 0.2 µm). An increase in surface roughness above this threshold roughness resulted in a simultaneous increase in plaque accumulation, thereby increasing the risk for both caries and periodontal inflammation [(19)].

In this research the samples were not subjected to any surface treatment, in order to avoid the influence of finishing techniques on the results. Only a polyester strip was used on the resin composite before polymerization with the intention of obtaining a smooth surface. Any form of additional polishing could lead to an increase in surface roughness [(20)]. Gonçalves et al. [(21)] presented that, the smoothest resin surfaces were obtained after the photopolymerization of the composites through the polyester matrix strips.

There are two variable present in this study, treatment solution (mouth rinses) and composite resins.

Effect of mouth rinse

Mouth rinses contain water, antimicrobial agents, salts, preservatives and in some cases alcohol or fluoride, the variation in the concentration of these substances affects the pH of mouth rinses [20]. It has been found that low-pH mouth rinses with higher alcohol content may affect some physical-mechanical properties of resin composites, producing softening of esthetic restorative materials[22].

All types of mouth rinses contain solvent such as water or alcohol, and this solvent enter the polymer network through porosities and intermolecular spaces and cause expansion that can affect the dimensions of the restorations. In addition, solvent uptake is accompanied by a loss of unreacted components, like unreacted monomers, or ions from filler particles, results in a loss of mass. [2]

Listerine have low pH (4.2) because of containing benzoic acid with high alcohol percentage, alcohol is a good polymer chain solvent, and solutions with high alcohol concentration can degrade the mechanical properties and increase the wear of composite resins [23], filler tend to fall out from resin material and the matrix component decomposes when exposed to low PH environment [24].

Although, the pH of Synsodine pronamel mouth rinses(6.2) is lower than that of Listerine (4.2) but there was no significant difference between them, this may be due to that sodium fluoride is as an active ingredient(450ppm)in Synsodine pronamel which may cause surface degradation. Fluoride agents with a low pH and a high fluoride concentration has been shown to cause surface damage to dental composites by dissolution and loss of filler particles, this may result in increased surface area exposure of the resin matrix [25], alsofluoride cause disorganization of the siloxane network formed from the condensation of intramolecular silanol groups, which stabilizes the interface. This may weaken the particle-matrix interface [26].

According to the results of this study, both mouth rinses irrespective of the presence or absence of alcohol resulted in significant increase in the surface roughness of the tested resin composite materials compared to control with no significant difference between them.It was found that alcohol is not the only factor that has a softening effect on the restorative materials. Other ingredients in mouth rinses such as solvents, fluoride and acids may have softening effect on polymer matrix [27]**.**The finding of the present study is agreed with the result of Jyothi et al. [23]who reported that degradation of the composite resins are not significantly affected by the type of the mouth rinses used.

Effect of composite resin type

In this study; two dimethacrylates based composite resins, Filtek™ Z350 XT and Filtek™ p60 were compared with a silorane-based, Filtek™ p90 low shrink posterior composite. The two methacrylate based composite types tested in this study had the same polymer matrix composition: bis-GMA, UDMA, and bis-EMA resins. Except for bis-EMA, which is an ethoxylated version of bis-GMA, other molecules (bis-GMA, UDMA, and PEGDMA) have hydroxyl groups which promote water sorption. Moreover, the incorporation of TEGDMA in Filtek™ Z350 XT composite material resulted in an increase in water uptake as this monomer presents higher hydrophilicity when compared with bis-GMA and UDMA [28];so the lowest surface roughness of then a nofilled composites, Filtek™ Z350 XT, could be explained be the presence of TEGDMA and the (size, shape, and amount of)filler particles present in the compositions of the materials (Table 1). The composition and size of the filler particles affect the surface smoothness .The surface roughness increased as the filler sizes will be increased [29].Therefore, it can be expected that nanocomposite with a smaller particle size, will have a smoother surface. However, in the present study, the nanofilled composite resin type (Filtek™ Z350) showed lowest roughness values. This could be due to the nature of the resin matrix and the possible porosity in aggregated filler particles [30]. Filtek™ Z350contains comparatively small nanoclusters, producing a greater surface area to volume ratio and hence a larger area of hydrophilic silane available for water sorption. Consequently, the physicochemical properties of the intermediate phase will become more critical since a higher degree of silanisation will be required for resin-based composite with a high volume percentage of nanoparticles [31]**.**

Filtek™ Z350 XT might absorb more water at the filler–matrix interface. The absorbed water causes filler–matrix debonding or hydrolytic degradation of the filler [30]. The Nanofillers are discreetly dispersed or organized in clusters; these purely inorganic clusters are formed by individual primary nanoparticles bonded between them by weak intermolecular forces [32].

These findings are in accordance with previous studies concluding that then a nofilled composites have the lowest surface roughnessas compared with these two filling materials [33-35].

The result of the present study shows that silorane based resin composite and packable resin exhibited similar surface roughness in distilled water but there is highly significant difference between them after conditioning in both mouth rinses, since the mean Ra values of Filtek ™ P90 is higher than of Filtek™ P60.

Siloranes are silicon-based monomers with oxirane (epoxide) functionality. Siloirnes can be extrely hydrophobic, making the oxirane groups inaccessible to attack by water or water-soluble species [(36)], therefore decreasing solvent sorption [(28)]. However; there is a significant increase in surface roughness of silorane –based resin after immersion, this can be contributed to the filler load and composition.

The silorane-based resin composites presents filer particles of fine quartz particles and radiopaque yttrium fluoride, which make up 76% of its weight and which have an average size of 0.47µm and is classified as a microhybrid resin composite, this lower amount of filler particles as compared with Filtek™ p60 may have contributed to its ability to obtain higher surface roughness values than packable composite [(37)]. Han et al. [(38)] suggest that a relatively higher filler loading increase the stability of resin composite surface against low PH condition.

The presence of fillers in a polymer network can greatly affect solvent uptake and dissolution. Studies indicated that composites containing radiopaque glasses, such as Ba glass, Sr, Yb and La have been shown to undergo greater dissolution than silica and quartz containing resin composites [(2,39)].Garced et al. found that the highest values of ytterbium fluoride release were observed in the pH-cycling as compared to the deionized water medium [(40)].

This may explain the significant increase in roughness in Filtek™ P90 after immersion where Ytterbiumtrifluoride are part of their filler content. Ytterbium trifluoride, which contributes to fluoride release, is a water soluble component and leaches out after immersion in a solution [(30)]. This might alter the microstructure of the composite bulk through the formation of pores [(28)]. These findings are in agreement with results of other studies [(41,42)],that show the mouth rinses increase the surface roughness of silorane-based composite.

Filtek™ P60 has the higher filler loads with silica fillers type which has the lower dissolution as compared with other filler types but still there is a significant increase in surface roughness after immersion in mouth rinses this may contributed to the presence bis-GMA and UDMA hydroxyl groups which promote water sorption.

This in vitro study appears to show that mouth rinses utilization can significantly increase composite roughness but the average surface roughness of the tested materials in all circumstances didn't exceed the critical threshold value of 0.2µm, which allows plaque accumulation.

The results of the present study allow us to conclude that the changes observed in the composites depended on the material itself rather than the mouth rinse solution used.

REFERENCES

1. Rocha AC, Lima CS, Santos MC, Montes MA. Evaluation of surface roughness of a nanofill resin composite after simulated brushing and immersion in mouthrinses, alcohol and water. J Mat Res 2010; 13(1): 77-80.
2. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dent Mater 2006; 22(3):211-22.
3. Biradr B, BiradrS**,** Arvin MS .Valuation of the Effect of Water on Three Different Light Cured Composite Restorative Materials Stored in Water: An in Vitro Study. J Inter Dent 2012, Article ID 640942, 5 pages.
4. Silikas N, Kavvadia K, Eliades G. Surface characterization of modern resin composites: a multi technique approach. J Am Dent2005; 18: 95-100.
5. Costa J, Belusko AA, RileyK, Ferracane JL. The effect of various dentifrices on surface roughness and gloss of resin composites.J Dent 2010; 38: e123-8.
6. Manhart J, Chen HY, Hickel R. The suitability of packable resin-based composites for posterior restorations. J Am Dent Assoc 2001; 132(5): 639-45.
7. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. JADA 2003; 134:1382–90.
8. Beun S, Glorieux T, Devaux J, Vreven J, Leloup G. Characterization of nanofilled compared to universal andmicrofilled composites. Dent Mater 2007; 23(1):51-9.
9. Pérez MM, Ghinea R, Ugarte-Alván LI, Pulgar R, Paravina RD. Color and translucency in silorane-based resin composite compared to universal and nanofilled composites. J Dent 2010; 38: e110-6.
10. Marghalani HY. Effect of finishing/polishing systemson the surface roughness of novel posterior composites. J Esthet Rest Dent 2010; 22(2): 127-38.
11. Miranda D, Bertoldo CE, Aguiar FH, Lima DA, Lovadino JR. Effects of mouthwashes on Knoop hardness and surface roughness of dental composites after different immersion time.J Braz Oral Res 2011; 25(2):168-73.
12. Moran JM. Chemical plaque control-prevention for the masses. J Periodontol 2000; 15:109-17.
13. Festuccia MS, Garcia LF, Cruvinel DR, De-Souza FC.Color stability, surface roughness and microhardness of composites submitted to mouth rinsing action. J Appl Oral Sci 2012; 20(2):200-5
14. Ciccone-Nogueira JC, Borsatto MC, Souza-ZaroniW C, Ramos RP, Palma-Dibb RG. Microhardness of composite resins at different depths varying the post-irradiation time. J Appl Oral Sci 2007; 15(4): 305-9.
15. Davidsn CL, Schein MT, Zanchi CH, Rodrigues SA, Demarco FF.Composite resin microhardness: the influence of light curing methods, composite shade, and depth of cure. J Contemporary Dent Practice 2008; 9(4):1-6.

16. Wistrom DW, Diaz-Arnold AM, Swift EJ. Effect of fluoride on microhardness of glass ionomer restoratives. J Dent Res 1994; 73:258.
17. Celik C, Yuzugullu B, Erkut S, Yamanel K: Effects of mouth rinses on color stability of resin composites. J Euro Dent 2008; 2: 247-53.
18. Santos PH ,Pavan S , Suzuki TY,Briso AL,Assunção WG, Sinhoreti MA , Sobrinho LC,Consani S. Effect of fluid resins on the surface roughness and topography of resin composite restorations analyzed by atomic force microscope. J Mechanical Behavior of Biomedical Materials 2011; 4(3): 433-9.
19. Bollen CML, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater 1997; 13: 258–69.
20. Barbosa SH, Zanata RL, Navarro MFL, Nunes OB. Effect of different finishing and polishing techniques on the surface roughness of microfilled, hybrid and packable composite resins. J Braz Dent 2005; 16(1):39-44.
21. Gonçalves MA, Teixeira VC, Rodrigues S, Oliveira R, Salvio L. Evaluation of the roughness of composite resins submitted to different surface treatments.ActaOdontolLatinoam 2012; 25 (1):89-95.
22. Gurdal P, Güniz AB, Hakan SB. The effects of mouthrinses on microhardness and colour stability of aesthetic restorative materials. J Oral Rehabil 2002; 29(9):895-901.
23. Jyothi K, Crasta S, Venugopal P. Effect of five commercial mouth rinses on the microhardness of a nanofilled resin composite restorative material: An in vitro study.J Conserv Dent 2012; 15:214-7.
24. Al-Wahab Z N. An evaluation of the effect of different solutions on the microhardness of aesthetic restoration. J Med Dent 2011; 8(2):106-4.
25. El-Badrawy WA, McComb D, Wood RE. Effect of home-use fluoride gels on glass ionomer and composite resinrestorations. J Dent Mater 1993; 9: 63-7.
26. Papagiannoulis L, Tzoutzas J, Eliades G. Effect of topical fluoride agents on the morphological characteristics and composition of resin composite restorative materials. J Prosth Dent 1997; 77: 405-413.
27. Gürgan S, Onen A, Koprülü. In-vitro effect of alcohol-containing and alcohol-free mouth rinses of some restorative materials. J Oral Rehab1997; 24: 244-6.
28. Yesilyurt, C, Yoldas O, Altintas SH, Kusgoz A. Effects of food-simulating liquids on the mechanical properties of a silorane-based dental composite. J Dent Mater 2009; 28(3):362-7.
29. Marghalani HY.Effect of filler particles on surface roughness of experimental composite series.J Appl Oral Sci 2010; 18(1):59-67.
30. Nasim I, Neelakantan P, Subbarao C. Color stability of microfilled, microhybrid and nanocomposite resins—an in vitro study. J Color and Appear Dent 2010; 38(2): e137–e142.
31. Wilson KS, Zhang K, Atonucci JM. Systematic variation of interfacial phase reactivity in dental nanocomposites. Biomaterials 2005; 26:5095-103.
32. Mitra SB, Wu D, Holmes BM. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003; 134(10): 1382-90.
33. Abu-Naila AS. The effect of cyclic immersion in cola drinks on the surface microhardness and surface roughness of different composite resin filling materials. A master thesis, Department of Conservative Dentistry,College of Dentistry, University of Baghdad, 2010.
34. Jehad RH. Comparison of the effect of stannous fluoride and sodium fluoride on surface roughness of Silorane and methacrylate based restorative material using light polarizing microscope. J BaghColl Dentistry 2011; 23(2): 31-5.
35. Bansal K, Acharya SR, Saraswathi V. Effect of alcoholic and non-alcoholic beverages on color stability and surface roughness of resin composites: An in vitro study. J Conserv Dent 2012; 15:283-8
36. Eick JD, Smith RE, Pinzino CS, Kostoryz EL. Stability of silorane dental monomers in aqueous systems. J Dent 2006; 34: 405-10.
37. Ruschel VC, Basso G, Andrada M, Maia H. Effect of different polishing systems on the surface roughness and microhardness of a silorane-based composite. Applied Adhesion Science 2014; 2: 7.
38. Han L, Okamoto A, Fukushima M, Okiji T.Evaluation of flowable composite resin surfaces eroded by acidic and alcoholic drinks. Dent Mater 2008; 27(3): 455-65.
39. Asaka Y, Miyazaki M, Aboshi H, Yoshida T, Takamizawa T, Kurokawa H, Rikuta A. EDX fluorescence analysis and SEM observations of resin composites**.** JOS 2004; 46(3): 143-8.
40. Garcez RM, Buzalaf MA, Araujo PA. Fluoride release of six restorative materials in water and pH-cycling solutions. J Appl. Oral Sci2007**;** 15(5):406-11.
41. Ozer S, Tunc E S, Tuloglu N, Bayrak S. Solubility of two resins composite in different mouthrinses. BioMed Research International 2014:1-4.
42. Fernandez R A, El Araby M, Siblini M, Al-Shehri A.The effect of different types of oral mouth rinses on the hardnes of silorane based and nano-hybrid composites. J Sudi Oral Sci 2014; 1:105-9.