Tikrit Journal for Dental Sciences 11(2) (2023) 285-294
https://doi.org/10.25130/tjds.11.2.14
Tikrit Journal
for
Dental Sciences
https://tjds.tu.edu.iq
ISSN:2073-1213

Mouthwashes: Surface Hardness and Accuracy of Dual-cured Visible Light-Cured Composite

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Keywords:
dimensional accuracy, hardness mouthwashes, VLC composite.
Article Info.:
Article History:
Received: 28/3/2023
Received in revised form: 4/4/2023.
Accepted: 6/4/2023
Final Proofreading: 6/4/2023
Available Online: 1/12/2023

Citation: Muhsin SA, Yaseen IN. Mouthwashes: Surface Hardness and Accuracy of Dual-cured Visible Light-Cured Composite. Tikrit Journal for Dental Sciences 2023; 11(2): 285-294. https://doi.org/10.25130/tjds.11.2.14

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Abstract
In the oral environment, the longevity and durability of aesthe composite resin restorative materials are critical consideratic However, many studies have been done on the effect of cert mouthwashes on the surface hardness and accuracy of compo resin. Therefore, this study aims to examine the effect of GU alcohol-free and Listerine alcohol-contained mouthwashes on surface hardness and dimensional accuracy of cured and dual-cu visible light-cured composite.
Methods: Thirty-disc specimens of Nanohybrid light-cu composite resin were prepared according to ISO standardizat (4049/2000). The sample was divided into three groups (n=10), Control non-treated in distilled water; Alcohol-free GUM® a Alcohol-contained Listerine mouthwashes. The surface hardn and dimensional accuracy of specimens were measured at differ immersion intervals. These include initial immersion, after one a four weeks, and after the light dual-curing procedure. Data w analyzed via one-way ANOVA (post-hoc Tukey test) performec a significant P-value of ($p \leq .05$) and confidence level of 95%.
Conclusion: After the dual-curing process, the alcohol-free GU mouthwash showed a reduction in the surface hardness of composite material. Listerine mouthwash had a static reduction the composite specimen in diameters.

Introduction:

Under constantly varying concentrations, the organic and inorganic matrix of composite resins may alter inside the oral cavity. From an aesthetic perspective, light-cured composite resins were introduced in conservative dentistry to replace both acrylic resin and silicate. The curing reaction may initiate by light-emitting diodes to set [1], or a device with either blue light from a filtered halogen lamp; plasma arc units; or argon-ion lasers [2, 3]. The superior composite aesthetic and mechanical properties nominate it to restore anterior and posterior teeth in clinical practice [4]. Its strongest micromechanical bonding retention to tooth structure is shown to be simple to develop adhesion in the oral cavity [5].

The use of mouthwash has become very popular as a preventive agent to control some dental and periodontal diseases. Mouthwashes may contain antibacterial agents, flavours, humectants, and colourants in an aqueous or alcoholic medium [6]. Many studies documented that the restorative materials applied to tooth surfaces might affect by the chemical action of numerous types of food, drinks, and oral hygiene maintenance products [7-9]. The restorative materials in the oral cavity should have long-term durability with an adequate hardness to resist indentation or penetration [6, 10]. This may be associated with the strength, rigidity, and intraoral softening of this material in service [11, 12]. Also, many factors could contribute to the hardness of such materials as the chemical composition of the material itself, the material type, surface treatment, degree of conversion, storage time, and the chemistry of storage media [11, 13].

Clinically, the composite degradation might not relate to a singular factor or chemical substance. It could be the outcome of complex reactions between various factors. The degradation is a complicated process that is influenced by the polymeric matrix and filler particles [14-16] as well as other mechanisms like water uptake within the matrix, mechanical and thermal cycling, and crack propagation. The deterioration of the composite organic matrix is related directly to the presence of water [17-19]. The lower roughness and hardness mechanical properties of the composite resin result from its deterioration when water absorption and widespread process within the composite matrix take place [20, 21]. The hardness of the restorative material may attribute to its resin matrix or filler type [22] or the type and size of the filler particles. A reduction in the material hardness could result in premature failure of a restoration requiring its replacement [14, 23].

The clinical resilience of any composite resin may affect by the use of mouthwashes when acting as chemical softening agents [19]. Mouthwashes of low pH and high alcohol percentage may soften the composite matrix [21, 24] and lower the hardness of the composite resins [24]. On the other hand, Gürgan et al. reported that whether the use of alcohol-contain or alcohol-free mouthwashes may influence the hardness of the restorative [12]. Several studies suggested that Listerine as one of the commonly used mouthwashes may adversely affect the hardness of composite resin. This may relate to the high alcohol-content percentage of either ethanol or methanol [12, 25]. Material hardness is related directly to its strength and rigidity, and the clinical durability may be implicated due to chemical softening resulting from the use of some mouthwashes [26].

Following many studies, the hardness of some types of the composite was found highly affected by using Listerine mouthwash. This softening effect was found to directly adhere to the alcohol percentage [25, 27, 28]. On the other hand, in a study by Spuldaro et. al. and according to Gehlot et al, the hardness of composites could not be significantly related to alcohol percentage, and Listerine had no significant impact on the hardness of nanoparticles and micro-hybrid composite resin [29, 30]. Low pH reduces the microhardness of the polymer network and increases biodegradation over time. This could take place by catalyzing the ester groups found in dimethacrylate monomers in the composite resin matrix [22]. This was under the observations by many researchers who reported that the low pH and a high Listerine alcohol content affect the hardness of resin [31]. However, few studies claimed that the microhardness value of composite depends on the material itself rather than the rinsing solutions, and alcohol-contain mouthwashes have no adverse effect on the composite material [32, 33].

Few studies reported that an active ingredient in the mouthwashes like sodium fluoride may cause surface deterioration and reduction in the microhardness of composite [34, 35], also fluoride-containing mouthwashes can have an impact on the solubility of some composite restorative materials [17, 36]. On the other hand, many studies stated conflicting results regarding the impact of chlorhexidine-based mouthwashes on composite material hardness [37-39]. While in terms of light-curing exposure at both different storage intervals and mouthwashes, some studies discovered nearly identical Knoop hardness numbers [17, 40, 41]. Also, it may undergo significant volumetric shrinkage when polymerized [42, 43]. Therefore, the purpose of this research is to assess the effect of various types of mouthwash on the surface hardness and accuracy of light-cured and dual-cured composite resin.

Materials and methods:

Specimen preparation

A sample of 30 disc specimens of light-cured composite (Smile USA, shade A2) was prepared for this study with a dimension of 12(±0.02)× 3(±0.02) mm in diameter in thickness respectively according to ISO standardization (4049/2000) [44]. This is to prepare a sample specimen of standard dimension.

The specimen was cured for 40 seconds on each surface side according to the manufacturer's directions using the light-cure unit (Ivoclar-Vivadent). Before beginning the mouthwash procedure, all specimens were kept in distilled water for 24 hours without being finished. The sample was divided into 3 main groups (n=10). Group A: control group, no treatment (distilled water); Group B: alcohol-free GUM® mouthwash (Ivohealth, South Africa); and Group C: alcoholic Listerine mouthwash (Johnson and Johnson, UK). All the specimens were kept in numbered plain tubes until the time of treatment, Fig. (1).

Treatment with mouthwash

The specimens were stored in distilled water for 24 hours. They were then submerged in a 1ml mouthwash for 2 minutes per day for 1 week (7 days±2h), followed by a 4 week (28 days±2h) immersion. Finally, for 40 seconds, the treated specimens were dual-cured.

Testing procedures

The specimens were tested for surface hardness and dimensional accuracy to assess the impact of mouthwash on the light-cured composite filling material.

For surface hardness, one surface for each specimen was selected to measure the surface hardness. Each specimen surface was measured using a Shore D surface hardness tester unit (China) [45], Fig. (2). The specimens were measured after each immersion period for all treated groups including the control group. Also, they were measured after specimen dual-curing using a light-cure unit. While testing the dimensional accuracy, each specimen's diameter and thickness were measured using a digital calliper device with 0.001 mm accuracy (China). The specimens were measured before the surface hardness test, and after each immersion period for all treated groups including the control group. Also, all the specimens were measured after dual-curing by a light-cure unit. All specimens were measured three times, and the average of 3 readings was calculated for each specimen. The data were evaluated using one-way ANOVA (post-hoc Tukey test) with a significant P-value of ($p \leq .05$) and a 95% confidence level.

Results:

Tables (1) and (2), and Fig. (3) and (4) show the results of surface hardness and accuracy of VLC composite filling study groups initially, after treatment with both distilled water (control group) and after immersion in GUM® and Listerine mouthwash liquids for 1 week, 4 weeks and after dual-curing (light-curing). Following the comparison of the outcomes, there was a non-significant difference in the surface hardness in the control group, and between the treated groups, before treated, and after being treated with both GUM® and Listerine mouthwash ($p > 0.05$). However, there were statistically significant differences ($p < 0.05$) in the surface hardness of dual-cured composite filling that was treated with GUM® mouthwash than that of the initiative before the treatment procedure with a mean hardness difference of 3.9333.

For the dimensional accuracy, there were statistically non-significant differences in dimensional accuracy in diameter and thickness between the tested groups, before treated, and after being treated with both GUM® and Listerine mouthwash ($p > 0.05$). However, the diameter of the composite specimens that were dual-cured by the light-cure unit after being treated with Listerine mouthwash liquid showed statistically significant differences ($p < 0.05$) from that of the initial and that after 4 weeks with mean diameter difference of 0.0430 mm and -0.0477 mm respectively. Besides, it shows statistically significant differences between that week 1 and week 4 with a diameter mean difference of 0.0590 mm.

Discussion:

The variability in the present results was consistent with other studies which showed that several variables can influence the surface hardness and dimensional accuracy of dental composite materials. These may include composite type (matrix and filler type and particle size); mouthwashes type (alcohol-containing and alcohol-free); curing (depth, intensity, exposure time, and temperature); time of immersion, dimension of each specimen; period of study; and surface smoothness of each specimen. Many studies have discovered that water is directly linked to composite organic matrix deterioration. The absorption of this liquid causes a pervasive process within the composite resin matrix that causes degradation and results in reduced physical and mechanical properties, particularly those related to resin hardness [17-19]. Although, according to this study, there was no reduction in surface hardness observed within distilled water group (control group) initially, after immersion of the composite filling in distilled water after 1 week, 4 weeks and after dual-curing.

This also could be related to the chemical composition of the composite resin used in this study. The nano clustering of the hybrid filler particles reduces interstitial spaces that prevent the accumulation of water molecules in the micro space [20]. This may disagree with [21] who stated that such accumulation of water may results in a reduction in the hardness as well as leaching out a component as filler. Alcohol is known to smooth the surface of composite resin by removing monomers from the polymer structure. It may also open up the polymer structure, allowing water to diffuse, which can result in a decline in hardness, a rise in material wear, and changes in other physical properties [28]. Therefore, alcohol has a clear influence on the hardness properties. This could be in agreement with many studies [24], while in this study no differences in surface hardness were observed when Listerine mouthwash was used. This may agree with [29] and [30] as there were no differences in surface hardness comparison before immersion in Listerine mouthwash and after 1 week, 4 weeks of treatment, and after dual-curing. Also, no differences were noticed in the comparison between 4 weeks of Listerine treatment and after dual-curing. The chemical resistance of composite resin can be hampered by its makeup. As a result, the materials may be more or less prone to softening and degradation. In addition to the chemical composition, the chain type and crosslink density produced during the polymerization process [15] as well as the type and size of the filler particles [14, 23], influence the resistance of the dental composite resin. The homogenous filling of resin matrix (Bis-Gma and polycarbonate) by filler which is (high strength barium borosilicate glass and silica-zirconia of nanoparticles) may make the resin composition more resistant to hydrolysis [20]. The combination of two types of nanoparticles fillers (high-strength barium borosilicate glass and silica-zirconia filler) of nanoparticle size of 0.01 microns leads to the formation of nanoclusters decreases the interstitial area of the filler particles. This could raise the amount of composite loading and possibly enhance hardness. This study may be in agreement with Gehlot et al. 2022 as they reported that Listerine (alcohol-containing) does not affect the hardness of composite resin [30]. Yet, when the GUM®. mouthwash was used in the treatment, the composite filling showed no reduction in surface hardness when compared between the initial, after 1 week and 4 weeks. This could be occurring as a result of the nature of the composite filling that has been used; the type of mouthwash; or due to the limitation of the immersion time or period interval. After dual-curing, all the composite filling specimens treated by GUM® mouthwash found no reduction in the surface hardness when compared to that of the initial, after 1 week and 4 weeks. These findings may disagree with Pinheiroa et al. and Celik et al. discovered a nearly identical value of Knoop hardness number when composites were exposed to curing light at various time intervals after storage in different mouthwashes [17, 40]. This may occur also due to the type of fillers of composite resin that has been used in this study which includes barium borosilicate glass filler that has shown to be more susceptible to aqueous attack than those composite quartz fillers containing [14, 15]. Also, the second type of composite filler of this study is the silica/zirconia fillers, and this may explain their inferior performance against all the mouthwashes [16]. While a reduction in surface hardness was noticed after dual-curing might occur due to the interaction between chlorhexidine which is one of the GUM®. components, light, and temperature generated from the halogen curing unit used in this study [48]. Some studies showed that prolonged exposure to high temperatures or light should be avoided because this can be adversely affected by the stability of chlorhexidine solution [37, 38]. In this study, the sample dimensional accuracy including the diameter and the thickness has been measured to evaluate the changes due to the mouthwash components. However, no differences were noticed in all the tested groups. Such results could be related to the completed polymerization of the composite resin by light-curing or may be related to the limitations of the present study with a short study time of the period. Yet, the diameter of the composite resin affected by the treatment of Listerine mouthwash after dual-curing in comparison to that of initial and after 4 weeks of the treatment period, in addition to that between the 1st week and that of after 4 weeks. This may be due to the period of immersion, or to the presence of alcohol in Listerine mouthwash which may lead to wear. The type and composition of the mouthwash may soften the restorative substance matrix and interfere with the polymer-filler particle interface, increasing wear [37]. This may lead to the degradation of the material at the periphery of all specimens [18, 19]. This may occur due to limited light that penetrates these specimen's areas leading to less polymerization at the periphery. While both upper and lower flat surfaces of the specimens were subjected uniformly to light and well presented by no differences in thickness accuracy.

Conclusion:

Within the limitation of this study, it can be concluded that before the dual-curing process, both Listerine and GUM® did not affect the hardness and dimensional accuracy of the composite material (Smile, USA). However, there was an effect on dimensional accuracy with Listerine between the 1st and 4th week of the treatment study. Also, the specimens of GUM® mouthwash showed that the surface hardness of the composite material was reduced after the dual-curing procedure. Listerine also shows a static reduction in the composite specimen diameters. Further research was required to determine the effect of long-term mouthwash use on the micro-hardness and wearability of such composite materials.

Conflict of interest: None.

Fig. (1): Composite specimens kept in plain tubes, distilled water, GUM®, and Listerine **mouthwash.**

Fig. (2): Surface hardness (Shore D) testing unit

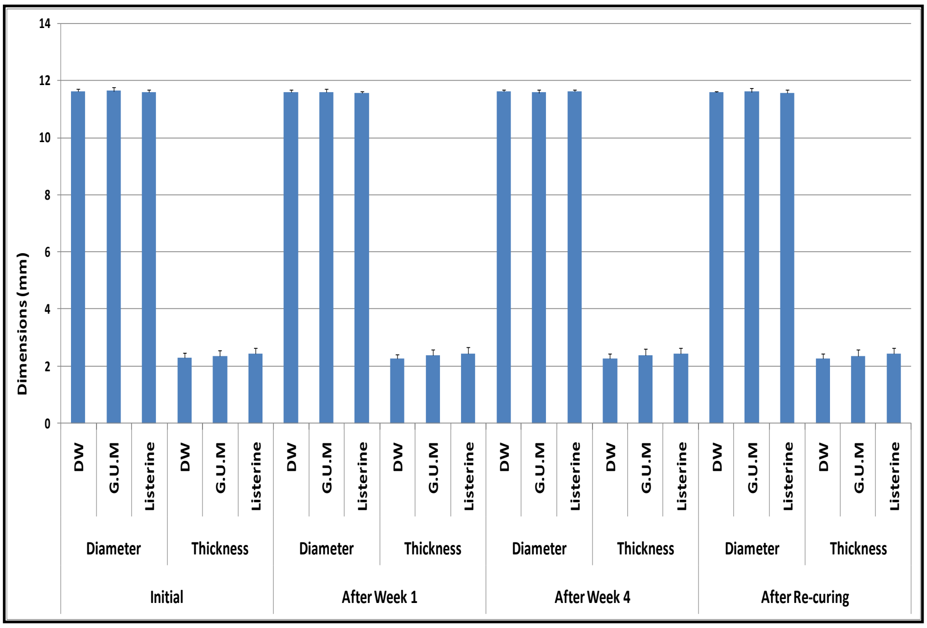

Fig. (3): Mean distribution of the surface hardness of the tested groups

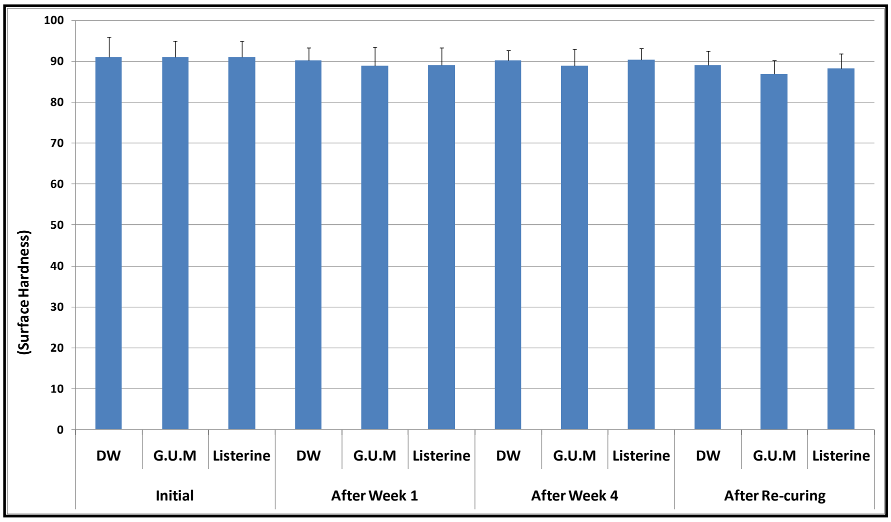

Fig. (4): Mean distribution of the dimensional accuracy of the tested groups

Table (1): ANOVA-test showing the surface hardness of the tested group specimens

Mouthwash	Groups		Mean Diff.	*P*-Value
Distill Water	Initial	Week1	.2833	.992 [NS]
		Week4	.3333	.985 [NS]
		Dual-curing	1.4333	.522 [NS]
	Week1	Week4	.0500	1.000 [NS]
		Dual-curing	1.1500	.519 [NS]
	Week4	Dual-curing	1.1000	.494 [NS]
GUM®	Initial	Week1	1.8667	.255 [NS]
		Week4	1.9333	.227 [NS]
		Dual-curing	3.9333*	.001 [S]
	Week1	Week4	.0667	1.000 [NS]
		Dual-curing	2.0667	.176 [NS]
	Week4	Dual-curing	2.0000	.200 [NS]
Listerine	Initial	Week1	1.4000	.458 [NS]
		Week4	.1000	1.000 [NS]
		Dual-curing	2.2333	.093 [NS]
	Week1	Week4	-1.3000	.523 [NS]
		Dual-curing	.8333	.817 [NS]
	Week4	Dual-curing	2.1333	.118 [NS]

Table (2): ANOVA-test showing the dimensional accuracy of specimen's tested groups

Mouthwash	Groups		Diameter		Thickness	
			Mean Diff.	P-Value	Mean Diff.	*P*-Value
Distill Water	Initial	Week1	.0247	.481 [NS]	.0430	.725 [NS]
		Week4	.0157	.799 [NS]	.0323	.861 [NS]
		Dual-curing	.0440	.056 [NS]	.0387	.784 [NS]
	Week1	Week4	-.0090	.953 [NS]	-.0107	.994 [NS]
		Dual-curing	.0193	.676 [NS]	-.0043	1.000 [NS]
	Week4	Dual-curing	.0283	.357 [NS]	.0063	.999 [NS]
GUM®	Initial	Week1	.0493	.396 [NS]	-.0060	.999 [NS]
		Week4	.0570	.269 [NS]	-.0193	.982 [NS]
		Dual-curing	.0290	.791 [NS]	.0007	1.000 [NS]
	Week1	Week4	.0077	.995 [NS]	-.0133	.994 [NS]
		Dual-curing	-.0203	.915 [NS]	.0067	.999 [NS]
	Week4	Dual-curing	-.0280	.808 [NS]	.0200	.981 [NS]
Listerine	Initial	Week1	.0317	.154 [NS]	.0017	1.000 [NS]
		Week4	-.0160	.709 [NS]	.0120	.996 [NS]
		Dual-curing	.0430*	.025 [S]	.0130	.995 [NS]
	Week1	Week4	-.0477*	.010 [S]	.0103	.997 [NS]
		Dual-curing	.0113	.873 [NS]	.0113	.997 [NS]
	Week4	Dual-curing	.0590*	.001 [S]	.0010	1.000 [NS]

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