The Effects of Polishing and Home Bleaching on Surface Roughness of Composites

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Abstract

The aim of this study was to investigate the effect of both polishing and home bleaching agent on the surface roughness of two different composite brands.

Two types of direct composite restorative material of A2 shade were selected for this study: Filtek Z250 XT nanohybrid universal composite restorative material (3M ESPE) and Tetric N-Cream nanohybrid universal composite restorative material (Ivoclar Vivadent). Thirty specimens were prepared from each composite material represented by the letter A for 3M composite and the letter B for Tetric composite (total number of specimens were 60). Each specimen was prepared by compressing sufficient amount of material into a mould of 5 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 composite top surface with LED Woodpacker light curing unit for 20s with an LED of output 600 mW/cm2. The bottom surface of each sample were marked. All samples were stored in plastic containers with 2ml distilled water for 24 hours at room temperature. The thirty specimens of each group were sub divided into three subgroups (n=10): A1/B1 were the control subgroups (cured only), A2/B2 were the polished subgroups (cured and polished) and A3/B3 were the bleached subgroups (cured, polished and bleached) which were bleached using home-type bleaching agent containing 9.5% hydrogen peroxide (PHILIPS ZOOM /DayWhite).Then, surface roughness of the 60 samples (top surfaces) were measured and recorded (Ra) value in µm using a profilometer surface roughness tester (Mitutoyo Surftest SJ-400). Data was statistically analysed by comparing surface roughness values of the sixty specimens for their tops with one way ANOVA and t-test at 5% level of significance.

Statistical analysis of the data revealed that, there was a statistically significant difference between the 6 subgroups being tested in their surface roughness values (ANOVA, $p \leq 0.05$) for their tops surfaces.There was a statistically significant increase in the surface roughness of the polished composite samples after being bleached with 9.5% hydrogen peroxide.There was insignificant difference (Paired Samples Test $p \geq 0.05$) in the surface roughness between the two major groups A & B.

Polishing of composite restorative material is an important step to be done before and after bleaching procedure in order to minimize the surface roughness that can lead to biofilm accumulation and stains retention. Clinically, there is no need to replace composite restorations after bleaching from surface roughness aspect.

Knowledge about the effect of bleaching on the properties and behaviour of composite resins is important to use the most suitable composite resin for restoration of teeth undergoing bleaching. By doing so, the need for composite resin restoration change due to possible complications caused by bleaching treatment is obviated.

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Introduction

Since long time, composite resins were introduced and now dominate the materials used for direct esthetic restorations. One of the most important dentist responsibilities is to select the appropriate composite material that might resist future challenges during its clinical service inside the patient's mouth due to frequent prophylactic treatment like polishing or cosmetic treatment like bleaching. The dental professionals shall also choose the best materials as well technique that meet patient's expectations as a successful restoration under different clinical circumstances. Changes in surface roughness, microhardness, compressive and diametral tensile strength (DTS) are commonly used to study the possible adverse effects of bleaching agents on direct composite restorative materials [1, 2.] Increase in surface roughness enhances the accumulation of food and biofilm formation and increases the risk of periodontal disease. Evidence shows that bacterial accumulation directly depends on surface roughness [3.] There are many properties that paly a strategic role related to surface roughness of composite restorations such as filler type, filler size, monomer type and percentage. Finishing and polishing also affect surface roughness of composite restorations[4.]

Vital and non-vital tooth bleaching has a long and successful history. Bleaching treatment offers in the forms of at-home or in-office bleaching with the use of carbamide peroxide (CP) and hydrogen peroxide (HP), respectively[5.] About 15% CP is the most commonly used bleaching agent for at-home bleaching, while manufacturer's data indicating that, Zoom home-bleaching agent containing 9.5% (HP). Hydrogen peroxide is considered as an active and important factor of teeth bleaching. Hydrogen peroxide (H_2O_2) is released when the carbamide peroxide breaks down as it contacts the water [6.] Studies on the effect of bleaching agents on the surface roughness of dental materials have reported controversial results [7-9.] The effects of bleaching on resin-based materials depend on the type of resin, composition of the bleaching gel, and duration and frequency of exposure [8, 10, 11.]

The aim of this study is to investigate any significant change in surface roughness values of two composite brands after being polished and home bleached.

Materials and methods

Two types of direct composite restorative material of A2 shade were selected for this study: Filtek Z250 XT nanohybrid universal composite restorative material (3M ESPE) and Tetric N-Cream nanohybrid universal composite restorative material (Ivoclar Vivadent) (Figure 1).The composition of each composite material is listed in Table 1. Thirty specimens were prepared from each composite material represented by the letter A for 3M composite and the letter B for Tetric composite (total number of specimens were 60). Each specimen was prepared by compressing sufficient amount of material into a mold of 5 mm in diameter and 2 mm in thickness (Figure 2) 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 composite top surface with LED Woodpacker light curing unit for 20s with an LED of output 600 mW/cm^2.

Figure 1. The two types of composite materials used in the study.

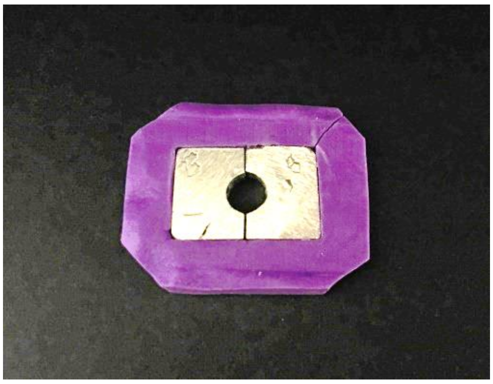

Figure 2. The metal mold (5 mm in diameter X 2 mm in thickness) used in the study.

The bottom surface of each sample were marked. All samples were stored in plastic containers with 2ml distilled water for 24 hours at room temperature. The thirty specimens of each group were sub divided into three subgroups (n=10): A1/B1 were the control subgroups (cured only), A2/B2 were the polished subgroups (cured and polished) and A3/B3 were the bleached subgroups (cured, polished and bleached) which were bleached using home-type bleaching agent containing 9.5% hydrogen peroxide (PHILIPS ZOOM /DayWhite). Twenty samples of Filtek composite A2/A3 and twenty samples of Tetric composite B2/B3, were polished using medium and fine polishing discs (OptiDisc-Kerr) with low speed handpiece. Each sample was polished two times in one-way motion (not back and forth); initially with medium disc and then with fine disc. Each disc was used for three polishing times and then discarded [12].

Composite brand	Filler type	Resin type	Filler % By weight	Filler % By volume	Composition
Filtek Z250 XT Nano Hybrid Universal composite	Particle size of 20 nm for the silica and approximately 0.1 - 10 microns for the zirconia/silica.	BIS-GMA, UDMA, BIS-EMA, PEGDMA, and TEGDMA resins.	81.8%	67.8	A combination of surface modified zirconia/silica
Tetric N-Cream Nano hybrid universal composite	Particle size of inorganic fillers is between 40 nm and 3000 nm. barium glass, ytterbium trifluoride, mixed oxide and copolymers	dimethacrylates (19-20 wt. %)	80-81	55-57	Additives, catalysts, stabilizers and pigments are additional contents (<1 wt. %).

Table 1. Composite materials composition used in this study (manufacturer's data).

Ten samples of Filtek composite A3 and ten samples of Tetric composite B3, were polished and bleached using home-type bleaching agent containing 9.5% hydrogen peroxide (PHILIPS ZOOM /DayWhite). A thin layer (about 1mm) of whitening gel was applied on the top surface of each sample using whitening gel syringes with their mixing tips. Then, samples were rinsed and dried for the next cycle. Whitening gel was applied on each sample for 30 minutes, two times per day for 14 days according to the manufacturer instructions. Surface roughness of the 60 samples was measured using a profilometer surface roughness tester (Mitutoyo Surftest SJ-400). Profilometer device tip was in contact with the sample during the measurement process. Once the tip becomes in contact with sample surface, it moves a distance of 0.25 mm (Cutoff length) and gives the roughness average (Ra) value in µm. Three measurements from three different regions within the same sample were done and the average of them was taken as the surface roughness value (Ra) of the sample. Data was statistically analyzed by comparing surface roughness values of the sixty specimens for their tops with one way ANOVA and t-test at 5% level of significance.

Results

Mean surface roughness (Ra) values in µm of the six subgroups (A1-A3, B1-B3), standard deviations listed in Table (2). Figure 3 represents mean surface roughness (Ra) values of the six subgroups being tested in this study. One-way ANOVA test revealed that there was a statistically significant difference between the three subgroups of group A & B respectively ($P \leq 0.05$) Table 3. Further analysis of the data was done using Paired Samples Test (Table 4) indicated that there was statistically insignificant differences ($P \geq 0.05$) between A and B major groups.

Group/Sub group		N	Mean	Std. Deviation	Minimum	Maximum
A	1	10	**0.14**	0.07	0.04	0.26
	2	10	**0.09**	0.02	0.05	0.13
	3	10	**0.85**	0.19	0.48	1.15
B	1	10	**0.11**	0.04	0.04	0.17
	2	10	**0.07**	0.02	0.04	0.11
	3	10	**0.72**	0.21	0.34	1.06

Table 2. Mean surface roughness (Ra) in µm, standard deviations values of the six subgroups (A1-A3, B1-B3).

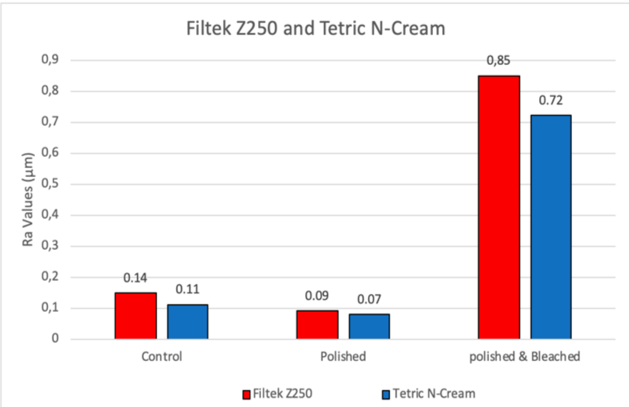

Figure 3. Mean surface roughness (Ra) values in µm of the six subgroups being tested in this study.

Further analysis of the data was done by using t-test through which, each pair of subgroups was individually compared apart from other subgroups, to indicate statistically significance/ insignificance differences between the individually. T-test indicated all pairs being tested showed statistically significant differences (P ≤ 0.05) except pairs no. 4, 7, 8 and 9 showed statistically insignificant differences (P ≥ 0.05) Table 5.

ONE WAY ANOVA							
Group		Sum of Squares	df	Mean Square	F	Sig.
A	Between Subgroups	3.578	2	1.789	123.76	0.00
	Within Subgroups	0.39	27	0.014		
	Total	3.969	29			
B	Between Subgroups	2.629	2	1.314	83.441	0.00
	Within Subgroups	0.425	27	0.016		
	Total	3.054	29			

Table 3. One way ANOVA of surface roughness (Ra) within each group A & B.

Paired Samples Test					
Group	Paired Differences		t	df	Sig. (2-tailed)
	Mean	Std. Deviation			
A - B	0.05922222	0.20628939	1.572	29	0.127

Table 4. Paired Samples Test between A and B major groups.

Paired Samples Test (t-test)							
Group		Paired Differences		t	df	Sig. (2-tailed) P-value	Sig/ Insig
		Mean	Std. Deviation				
Pair 1	A1 - A2	0.05666667	0.06057339	2.958	9	0.016	Sig
Pair 2	A1 - A3	-0.70266667	0.21618922	-10.278	9	0.00	Sig
Pair 3	A2 - A3	0.75933333	0.18828531	12.753	9	0.00	Sig
Pair 4	B1 - B2	0.032	0.05782477	1.75	9	0.114	Insig
Pair 5	B1 - B3	-0.61133333	0.21644832	-8.931	9	0.00	Sig
Pair 6	B2 - B3	-0.64333333	0.21654412	-9.395	9	0.00	Sig
Pair 7	A1 - B1	0.037	0.08741062	1.339	9	0.214	Insig
Pair 8	A2 - B2	0.01233333	0.03103363	1.257	9	0.24	Insig
Pair 9	A3 - B3	0.12833333	0.34672809	1.17	9	0.272	Insig

Table 5. t-test showing Sig/ Insig by comparing each pair of subgroups individually.

Discussion

Bleaching is one of the most commonly used clinical procedures to improve the esthetics of vital teeth. Vital tooth bleaching can be performed in the office by the dentist using high concentrations (25–35%) of hydrogen peroxide (HP), or at home by the patient using lower concentrations (10–16%) of carbamide peroxide (CP) and HP[13]. In this study, we used 9.5% HP as being considered within the lowest concentration values among other brands of in home bleaching agents. From biocompatibility aspect, although bleaching is accepted as an efficient treatment and safe for soft tissues, it may not be safe for dental materials that have high erosive or degradation characteristics [14]. Some studies have shown that bleaching agent affect the surface roughness of composite [15, 16] by accelerating the hydrolytic degradation [17] and inducing oxidative cleavage of polymer chains in resin matrix [18] while other studies have not like the findings of Yikilgan et al., 2017 [19] who concluded that, there was no negative effect of glaze materials on the protection of surface roughness and hardness of composite resin was observed. Our results disagreed with the findings of Yikilgan et al. since our results showed significant change on polished composite surface roughness after exposure to bleaching material. The difference in our results and his results might be attributed to difference in composite materials used in his study (Charisma Diamond), different polishing system (Biscover LV) and also different bleaching agent (CP in office bleaching system) which affect the surface roughness results accordingly.

According to our study results, we found that there was a statistically significant difference in surface roughness of the polished composite samples after being treated with 9.5% hydrogen peroxide for both Filtek Z250 and Tetric N-Cream being tested as shown in Tables 3 and 5. This significant increase in surface roughness values could be attributed to the effect of hydrogen peroxide to produce free radicals by oxidization and reduction. The free radicals may interfere with the resin-filler interface resulting in debonding that leads to microscopic cracks causing an increase in the surface roughness [20]. HP can cause an increase in the composite surface roughness as a result of organic matrix erosion rather than the inorganic fillers [21]. Different organic matrix polymers, the inorganic filler content and the particle size are the factors that may cause the difference in surface roughness values of composites after being bleached [22].

In our study, we found that there was insignificant differences in the surface roughness between Filtek Z250 and Tetric N-Cream composites among the three subgroups (control, polished and polished & bleached) as shown in table 5 pairs 7-9 as Tetric N-Cream composite shows slightly lower surface roughness values compared to Filtek Z250 composite Figure 3 and this might be due to the slight difference in inorganic filler % by volume between them as Tetric N-Cream composite has lower filler content (55-57% by volume) compared to Filtek Z250 composite (67.8% by volume) Table 1. Our data agreed with Munteanu et al., 2014 [23] as the inorganic filler content of composite is directly proportional to the surface roughness as the composite with highest filler volume will have the highest surface roughness value.

Generally, as shown in Figure 3, polished composite samples have the lowest surface roughness values (0.09 & 0.07 µm) in this study among all subgroups for Filtek Z250 and Tetric N-Cream composites respectively. Polishing of composite samples has a significant effect on their surface roughness by reducing its values compared to the control group.

Conclusions

1. Home-type bleaching agent containing 9.5% hydrogen peroxide has significantly increased the surface roughness of both Filtek Z250 and Tetric N-Cream nanohybrid composites.
2. Between Filtek Z250 and Tetric N-Cream nanohybrid composites, there was insignificant differences in the surface roughness among the control, polished and polished bleached subgroups.
3. Polishing of nanohybrid composite samples has reduced the surface roughness among all the groups regardless of whether being Filtek Z250 or Tetric N-Cream.
4. Limitations in this study include: the study is in vitro and does not simulate the conditions of the oral cavity completely, samples size, equipment and materials.

Declaration of Interest

The authors report no conflict of interest.

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