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Integrated Master in Dentistry

Composites roughness and microhardness after different bleaching techniques

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ABSTRACT

Aims: The purpose of this study is to evaluate the surface roughness and microhardness of a recent nanohybrid composite, SonicFill™ (Kerr Corporation, Orange, USA), and compare it with another nanofilled, Filtek™ Supreme (3M ESPE, St. Paul, MN, USA) after the submission of both to the action of two bleaching agents: 10% carbamide peroxide and 35% hydrogen peroxide.

Methods and materials: Sixty cylindrical specimens (10mmx2mm) of each composite were prepared and stored in artificial saliva at 37ºC for 24 hours. The specimens were then polished and stored in artificial saliva at 37⁰C. After 24 hours, specimens were divided into 6 groups (n=20). Groups 1, 2: stored in artificial saliva. Groups 3, 4: 10% carbamide peroxide. Groups 5, 6: 35% hydrogen peroxide with LED lamp activation. 24 hours after treatments, specimens went through 500 cycles of thermocycling between 5ºC and 55ºC with a dwell time of 30 seconds. A mechanical roughness tester was employed to measure the surface roughness parameters and the Vickers test to measure microhardness on the top surface of each specimen.

One-Way-ANOVA, Tukey and Bonferroni methods with a significance level of 5% were used for the statistical analysis.

Results: For SonicFill™, there was no statistically significant difference in microhardness between the control group (1) and the bleached groups (3, 5). However there was difference between home bleaching (group 3) and in-office treatment (group 5). For Filtek Supreme XTE™ there was no significant difference in microhardness among all groups.

In case of roughness, there was no significant difference in roughness average (R_a) and root mean square roughness (R_q) among all groups. The mean roughness depth (R_z) parameter showed no statistically significant differences among all groups for SonicFill™ but, in Filtek Supreme XTE™ there was a significant increase between control (group 2) and bleaching treatments (groups 4, 6). Roughness skewness (R_{sk}) showed no statistically significant differences among all groups for SonicFill™ and Filtek Supreme XTE™, except for groups 2 and 4, where the R_{sk} increased with CP.

Conclusion: The microhardness of Filtek Supreme XTE™ and SonicFill™ is not affected by bleaching treatments.

Both bleaching treatments affect R_z of Filtek Supreme XTE™ groups, in contrast to the SonicFill™ groups.

The carbamide peroxide 10% treatment affects the R_{sk} of group Filtek Supreme XTE™ with no significant effect in the SonicFill™ group.

Keywords: tooth bleaching/ resin composite/ roughness/ microhardness

Introduction

The use of bleaching agents to improve the appearance of natural dentition has become a popular procedure since their introduction by Haywood and Heymann.(1)

Currently, bleaching agents are based primarily on hydrogen peroxide (HP) or its compounds such as carbamide peroxide (CP).(2-5) Bleaching agents provide bleaching of tooth structure through decomposition of peroxides into unstable free radicals.(6,7) These radicals further break down into large pigmented molecules either through an oxidation or a reduction reaction. The oxidation/reduction process changes the chemical structure of interacting organic substances of the tooth, which results in colour change.(8-10)

The tooth whitening treatment was classified by the American Dental Association into four categories: professionally applied (in the dental office); dentist-prescribed/dispensed (patient home-use); consumer-purchased/over-the-counter (OTC) (applied by patients); and other non-dental options.(2)

In-office bleaching materials contain high hydrogen peroxide concentrations (typically 15-38%), while the hydrogen peroxide content in at-home bleaching products usually ranges from 3% to 10%.(2) In general, most in-office and dentist-prescribed at-home bleaching techniques have been shown to be effective, although results may vary depending on such factors as type of stain, age of patient, concentration of the active agent, and treatment time and frequency.(2)

However, the application of bleaching agents can affect human teeth and restorative materials.(3,11,12)

Many studies have examined the changes caused by bleaching in the properties of composite resins, a material commonly used for aesthetic dental treatments, such as colour, surface hardness and roughness, staining susceptibility, microleakage and elution.(11)

Hardness is defined as the resistance of a material to indentation or penetration.(13) Surface hardness is one of the most important physical characteristics of dental materials.(14,15) Since hardness is related to a material´s strength, proportional limit, and ability to abrade or to be abraded by contralateral dental structures/materials, any chemical softening resulting from bleaching may have implications for the clinical durability of restorations.(16)

Furthermore, surface roughness is also considered an important property of dental materials[17-19] and an important factor of aesthetic appearance.(15) Materials with roughened surfaces enhance bacterial adhesion, having a smaller free surface energy.(18) In addition to promoting plaque adherence, roughened materials also suffer from increased staining.(18)

Controversial results about the effects of bleaching on the surface roughness and microhardness of resin composite have been reported in literature.(3,10,12,16,18,20-43)

The resin composite, SonicFill™ (Kerr Corporation, Orange, USA), was recently introduced in the market. It is indicated for use as bulk fill in posterior composite restorations and can be bulk filled in layers up to 5mm in depth due to reduced polymerization shrinkage. SonicFill^{TM} incorporates a highly-filled proprietary resin with special modifiers that react to sonic energy. As sonic energy is applied through the handpiece, the modifier causes the viscosity to drop (up to 87 %), increasing the flowability of the composite enabling quick placement and precise adaptation to the cavity walls. When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state that is perfect for carving and contouring.(44)

The aim of the current study was to investigate the effect of 35% hydrogen peroxide and 10% carbamide peroxide on the surface roughness and microhardness of this recent resin composite, SonicFill™, and compare it with a nanofilled composite, Filtek ™ Supreme (3M ESPE, St. Paul, MN, USA).

METHOD AND MATERIALS

Specimen Preparation

One hundred and twenty composite disks were prepared with 10mmx2mm (diameter/thickness), using an acrylic mould (Figure 1).(41) The colour corresponding to shade A3 was used for every material (Figure 2 and 3). The resin composite (Table I) was inserted in only one increment. Each surface was covered with a glass slab to allow flushing of the excess material and to obtain a smooth upper surface of the sample.(20,23,25,32) Specimens were then photopolymerized with a halogen light polymerizing unit (Bluephase® - Ivoclar Vivadent AG, FL-9494 Schaan, Liechtenstein) with light intensity of 1500 mW/cm^2 ± 10% using 40 seconds for nanofilled composite and 20 seconds for nanohybrid, in accordance with the manufacturer's instructions. The curing light intensity was verified with a radiometer (Bluephase® meter - Ivoclar Vivadent, FL-9494 Schaan / Liechtenstein). All specimens were stored in artificial saliva at 37^{0}C for 24 hours to ensure complete polymerization.(31)

The composite disks were polished with polishing disks (Super-Snap Rainbow® Technique Kit - Shofu Inc., Kyoto, Japan) in descending order of granulation. Each polishing step was performed on a slow-speed handpiece in accordance with the manufacturer's instructions. After polishing, the specimens were stored in artificial saliva at 37^{0}C for 24 hours (Figure 4). The composition of the artificial saliva, used in this study, is: potassium cloride: 20.1 m mol/L; sodium hydrocarbonate: 17.9 m mol/L; sodium dihydrogen phosphate: 3.6 m mol/L; potassium thiocyanate: 5.1 m mol/L; lactic acid: 0.10 m mol/L and distilled water.(45)

Table I: Resin composites used in this study.(46-48)

Resin Composites		**Nanofilled composite**	**Nanohybrid composite**
Product name, Manufacturer		Filtek™ Supreme XTE, 3M ESPE, St. Paul, MN, USA	SonicFill™ Kerr Corporation, Orange, USA
Main composition		Silane treated ceramic, silane treated silica, diurethane dimethacrylate (UDMA), bisphenol A polyethylene glycol diether dimethacrylate, bisphenol A diglycidyl ether dimethacrylate (BISGMA), silane treated zirconia, polyethylene glycol dimethacrylate, triethylene glycol dimethacrylate (TEGDMA), 2,6-Di-tert-butyl-p-cresol (BHT)	Glass, oxide, chemicals, 3-trimethoxysilylpropyl methacrylate, silicon dioxide, ethoxylated bisphenol-A-dimethacrylate, bisphenol-A-bis-(2-hydroxy-3-mehacryloxypropyl) ether, triethyleneglycoldimethacrylate
Loads	**Size**	4-20 nm	It is not available by manufacturer
	% by weight	78.5%	83.5 %
	% by volume	63.3 %	It is not available by manufacturer
Lot no.		N422474; N443370; N339166	N440317; N422474; N443370; N337197

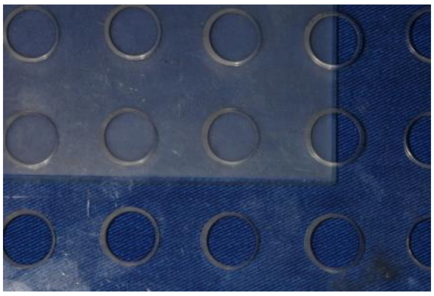

Figure 1. Acrylic mould and glass slab.

Figure 2. Nanohybrid composite SonicFill™ System.

Figure 3. Nanofilled composite Filtek™ Supreme XTE.

Figure 4. Specimens stored in artificial saliva.

Exposure to the superficial treatment

The specimens were then randomly divided into 6 groups (n=20), shown in table II.

Groups 1 and 2: specimens were stored in artificial saliva at 37^{0}C for 14 days and served as control. Saliva was changed daily.

Groups 3 and 4: specimens were treated with carbamide peroxide at 10% (Figure 5) for 8 hours per day during 14 days (Figure 6) each day after the active treatment period the specimens were rinsed with distilled water, for 1 minute, to remove the bleaching agent and stored in artificial saliva. During the test period, the specimens were kept at 37^{0}C.

Groups 5 and 6: specimens were treated with hydrogen peroxide at 35%, (Figure 8 and 9) for 15 minutes, in progressive program. First of all, PowerPrep+™ was applied for 3 minutes on the surface of specimens (Figure 7) according to the manufacturer’s recommendations. After this period, specimens were rinsed with distilled water and dried with an air jet. The procedure followed was to apply hydrogen peroxide at 35% on the surface of specimens. Bleaching agent was activated by a light emitting diode lamp (LED), White+™ lamp (Meodental, Prime Dental Manufacturing, Illinois, USA) (Figure 10). The bleaching treatment was conducted after 14 days storage in artificial saliva at 37^{0}C. After the active treatment period the specimens were rinsed with distilled water, for 1 minute, to remove the bleaching agent and stored in artificial saliva at 37^{0}C.

24 hours after the end of the treatments, specimens went through 500 cycles of thermocycling between 5ºC and 55ºC with a dwell time of 30 seconds.

Table II: Summary of control and experimental groups: bleaching systems on tested resin composites.

	Composites	
Bleaching System	**Nanohybrid composite**	**Nanofilled composite**
Control (Artificial saliva)	Group 1 n=20	Group 2 n=20
Opalescence®	Group 3 n=20	Group 4 n=20
White+™	Group 5 n=20	Group 6 n=20

Table III: Bleaching agents evaluated in this study.

Bleaching Agent		Type	Composition	Manufacturer	Lot no
Opalescence®		Home bleaching system	10% carbamide peroxide, glycerine, water, xylitol, carbomer, PEG-300, sodium hydroxide, potassium nitrate, EDTA, sodium fluoride.	Ultradent, South Jordan, UT, USA	474339
White+™	**Bleaching product**	Office bleaching system	35% hydrogen peroxide, water, polyethylen glycole, fumed silica, thickener, potassium nitrate, sodium fluoride, sodium hydroxide, dye, mineral dea sea salt.	Meodental, Prime Dental Manufacturing, Illinois, USA	2012-5786
	PowerPrep+™		Distilled water, citric acid, potassium nitrate, fumed silica, pigments.		

Figure 5. Bleaching agent - Opalescence®.

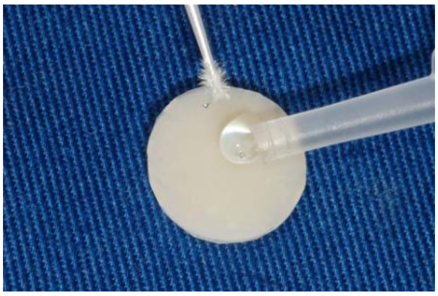

Figure 6. Bleaching agent, Opalescence®, was applied to the surface of specimens.

Figure 7. PowerPrep+™ was applied to the surface of specimens.

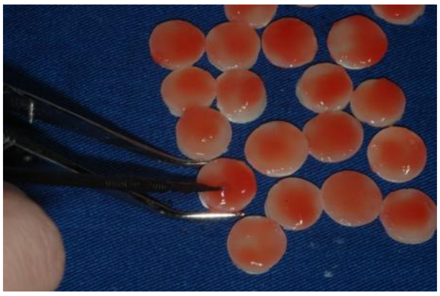

Figure 8. Bleaching agent, White+™ was applied to the surface of specimens.

Figure 9. Bleaching using White+™.

Figure 10. Bleaching activated by LED lamp.

Surface roughness analysis

The specimens were taken from the artificial saliva 24 hours after the end of the treatments. These procedures followed, specimens were rinsed with distilled water, dried with air jet and observed for directionality marks on the surface, a consequence of polishing, in an optical microscope.

Roughness measurements were performed according the DIN EN ISO 4288 standard, in which the monitored parameters are presented in Table IV. The measuring apparatus is a mechanical roughness tester, Mitutoyo Surftest- SJ-500/P Series 178. (Figure 11)

Table IV: Monitored roughness parameters.

Roughness parameters (μm)	
R_a	Roughness average
R_q	Root mean square roughness
R_z	Mean roughness depth
R_{sk}	Roughness skewness

In each sample 5 measurements were performed, evenly distributed along the surface and perpendicular to the previous one to minimize the influence of directionality (Figure 12).

Figure 11. Mitutoyo Surftest-SJ-500/P Series 178.

Figure 12. Measurements of roughness parameters.

Microhardness surface analysis

The hardness measurements were performed after the roughness analysis for each sample specifically to eliminate the influence of the Vickers indentations.

The measuring apparatus is a Struers Duramin-2 microhardness tester (Figure 13) and the measurements (Figure 14) were performed according to the Standard Test Method for Micro-indentation Hardness of Material (ASTM WK27978, 2010). The selected set of test conditions is also presented in Table V.

Table V: Select hardness test parameters

Hardness test parameters	
Load	0.2 Kgf - (1.962 N) - HV0.2
Time	40s

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Every sample was subject to 7 measurements, uniformly distributed, mainly to assure low dispersion hardness values.

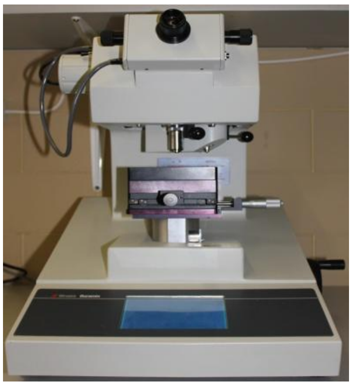


Figure 13. Struers Duramin-2 microhardness.

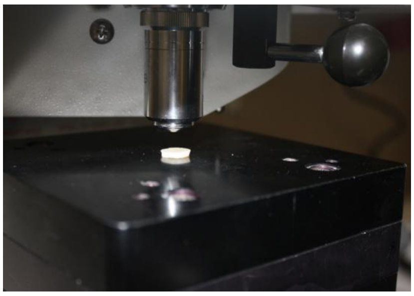


Figure 14. Measurements of microhardness.

Analysis of Variance (ANOVA)

The One-Way-ANOVA (one factor) was applied to the recorded data for comparison purposes. Two methods were used, Tukey and Bonferroni, suited for multiple comparisons between same groups. In every analysis was considered an confidence interval of 95%.

Results

Table VI presents the values of roughness parameters evaluated, microhardness and standard deviation for all tested groups.

Roughness measurements

When the data obtained from this study was subjected to statistical analysis, using One-Way-ANOVA, Tukey and Bonferroni methods with a significance level of 5%, it was observed that there was no significant difference in R_a and R_q among all groups tested (P>0,05).

R_z parameter showed no statistically significant differences among all groups for SonicFill™. However, in Filtek Supreme XTE™, there was a significant increase between control and bleaching treatments (Figure 15).

The R_{sk} showed no statistically significant differences among all groups for SonicFill™. In the case of Filtek Supreme XTE™ there was a statistically significant difference between the control group (group 2) and the group submitted to peroxide carbamide at 10% (group 4), where the R_{sk} increased with carbamide peroxide at 10%. (Figure 16)

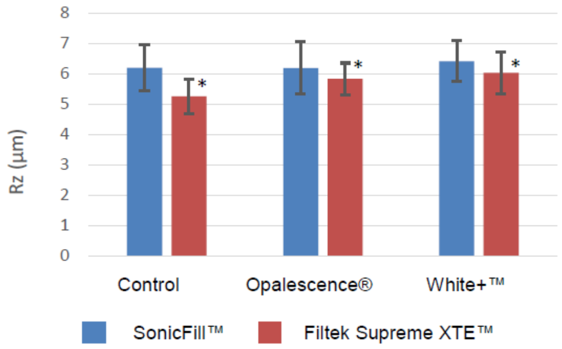


Figure 15. Mean roughness depth (µm) of all tested groups.

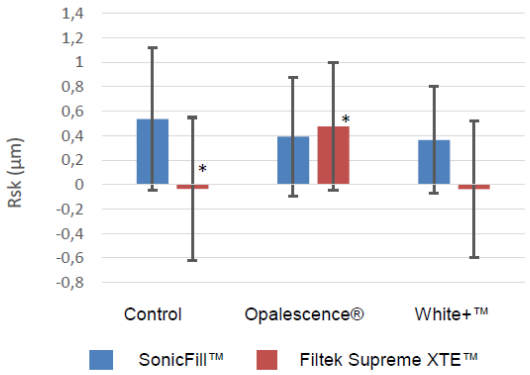


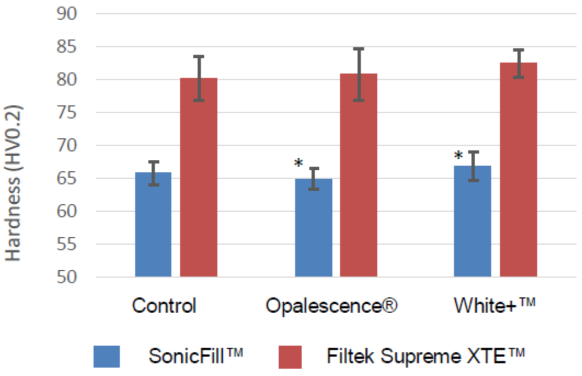
Figure 16: Roughness skewness (µm) of all tested groups.

***** Statistically significant difference**.**

Microhardness measurements

For SonicFill™, there was no statistically significant difference in microhardness between the control group (group 1) and the bleached groups (groups 3 and 5), but there was a difference between carbamide peroxide and hydrogen peroxide treatments. However, for Filtek

Supreme XTE™ there was no significant difference in microhardness among all groups (Figure 17).



***** Statistically significant difference.

Figure 17: Mean Vickers hardness values of all tested groups.

Table VI: Mean of different roughness parameters and microhardness evaluated of tested groups.

	Nanohybrid			**Nanofilled**		
	Control	**Opalescence®**	**White+™**	**Control**	**Opalescence®**	**White+™**
	Microhardness HV0.2					
Mean	65.8	64.9	66.9	80.2	80.9	82.5
SD	1.8	1.6	2.2	3.3	3.9	2.1
	Roughness average - R_a					
Mean	1.0264	0.9902	0.9597	0.8769	0.9976	0.9297
SD	0.2086	0.2180	0.1800	0.1899	0.1803	0.2056
	Roughness mean square - R_q					
Mean	1.3608	1.2948	1.2488	1.1479	1.3006	1.2042
SD	0.2882	0.2932	0.2458	0.2601	0.2204	0.2651
	Mean roughness depth - R_z					
Mean	6.1906	6.1770	6.4057	5.2497	5.8235	6.0270
SD	0.7651	0.8577	0.6813	0.5672	0.5197	0.6889
	Skewness - R_{sk}					
Mean	0.5338	0.3913	0.3629	-0.0371	0.4747	-0.0376
SD	0.5801	0.4875	0.4364	0.5846	0.5225	0.5597

SD- Standard deviation.

Discussion

Currently dentistry is experiencing a trend of increasing demand from patients for superior aesthetic restorations.(32) Very often in daily clinical practice, tooth colored restorations exist in teeth that are planned to be bleached.(35) Therefore, it is important to understand the effects of bleaching agents on the physical properties of the restorative materials.(32)

Various studies have been performed that deal with the effects of bleaching agents on composite resin. However, it is difficult to compare the results of those studies due to the variety of restorative materials used.(36)

Composite resins have been shown to be more prone to chemical alteration compared to inert metal or ceramic restorations, because of their organic matrix.(49)

The purpose of this study was to compare the surface roughness and microhardness of a recent nanohybrid composite with a nanofilled composite after the submission of both to the action of two bleaching agents: 10% carbamide peroxide and 35% hydrogen peroxide.

In this study, bleaching agents were applied with clinically relevant bleaching regimes, according to the manufacturer's recommendations. Between each bleaching treatment, the specimens were stored in 37ºC artificial saliva so that the specimens were not continuously exposed to bleaching products to simulate cumulative effects over time.

The impact of bleaching on surface microhardness of composites is described controversially in the literature. Increases(23,24,30) as well as decreases(10,12,21,28,30,37-41) in surface microhardness induced by home bleaching have been found, whereas other studies revealed no significant alteration.(3,27,32-35,50) Regarding in-office tooth whiteners, some studies showed that they did not significantly affect microhardness of composite materials(5,3,16,26,35,37) and other investigations reported a decrease.(39,42,43) The discrepancies between these studies may be explained by the differences in experimental methodologies, bleaching agents applied(25,33) and restorative materials used.(25,51) The frequency with which bleaching agents were changed may also contribute to the disparity between the results of the studies.(33,36)

Based on the statistical results of this study, the bleaching products used did not affect the microhardness of the resin composites evaluated. This result is in accordance with the findings of various studies(3,5,16,26,27,32-35,37,50), which reported that the microhardness of composite resin was not significantly affected by the use of bleaching agents. Yap and Wattanapayungkul et al(16) reported that no significant difference was observed in the microhardness level between the control and the bleached groups for all materials tested with in-office bleaching (carbamide peroxide at 35% and hydrogen peroxide at 35%). Silva Costa et al(3) indicated that microhardness after bleaching (home-bleaching and office-bleaching) in the nanofilled composite was not perceptible or significant. A recent study of

Mourouzis et al(15) showed that the bleaching procedure did not alter the microhardness of all composite resins tested. These resin composites had in their composition a high proportion and small size of fillers.(15)

However, there was a statistically significant difference in microhardness between home bleaching (group 3) and in-office bleaching regimen (group 5) in SonicFill™, in contrast to Filtek Supreme XTE™, where there was no difference among all groups. Group treated with hydrogen peroxide at 35% (group 5) showed statistically higher microhardness than the group that received the carbamide peroxide at 10% (group 3). Various studies have shown that composites which underwent a secondary heat treatment to increase the degree of polymerization showed higher hardness values than did composites that were light cured only.(13) Therefore, considering that microhardness is related to the degree of polymerization,(13) it is conceivable that an increase in microhardness may be due to an additional polymerization of residual monomers, with LED, used in in-office bleaching regimens.

As for microhardness, investigations on the surface roughness of resin composites after bleaching have shown contradictory results.(51) Some investigations reported that in-office bleaching adversely affected the surface roughness of composites.(21-24) Conversely, other studies reported that it was not detrimental to the surface roughness of composites.(18,25,26) Different results were also evident regarding the use of lower concentration home bleaching agents. Some investigations reported that home bleaching increases the surface roughness(27-29) and other investigations showed that composites could be safely bleached without compromising their roughness.(30,31)

Specific roughness parameters were selected in this study, according to the targeted results desired and ISO 4287-1997 standard, since the measurements were performed according to the DIN EN ISO 4288 standard.(52)

The arithmetical mean roughness (R_a) and root mean square roughness (R_q) present a fair representation of the typical surface profile for comparison reasons. Most of the studies only include R_a parameter for characterizing surface roughness. However, that parameter alone may not be sufficient to distinguish different variations, such as: it does not make a distinction between peaks and valleys; it does not qualitatively evaluate the form of the peaks and valleys; and, generally, it does not consider unusual peaks and valleys.(53)

Therefore, it is necessary to include other parameters in the analysis to overcome some setbacks related to the use of R_a alone.(53) The mean roughness depth (R_z) and roughness skewness (R_{sk}) can contribute to the differentiation by characterizing the depth between peak and valley and the quantification of each one. R_{sk} may be used to quantify the symmetry of the surface as it may relate to various considerations such as particulate retention. A surface with predominantly deep valleys will tend to have a negative skew, whereas a surface comprised of a disproportionate number of peaks will have a positive skew.(54,55) This parameter becomes quite relevant when considering that an area which features a predominance of depressions tends to accumulate a larger amount of materials on its surface.(54)

In this study, there was no significant difference in R_a and R_q among all groups tested ($P>0.05$). However, when R_z parameter was analysed, Filtek Supreme XTE™ showed a significant increase between control and bleaching treatments.

Because different compounds are present in both the organic and inorganic fractions of restorative materials, even in products that are similarly categorized, these materials can react differently to the same treatment.(17,56) This possibility was confirmed in this study.

Filtek Supreme XTE™, as a nanofilled composite, has an average particle size ranging from 4 to 20 nm, while a nanohybrid, as SonicFill™, has an average particle size ranging from 0.03 to 3 µm.(47,57) These characteristics may explain the different profilometric post-bleaching changes seen here. The filler load is directly related to the surface area that is taken up by filler particles versus resin matrix, as the surface smoothness is generally determined by the largest inorganic particles presented within the composite.(58) The total content of inorganic fillers of Filtek Supreme XTE™ (78.5% by weight) is lower than SonicFill™ (83.5% by weight) and might be another reason that this material is more susceptible to alteration during bleaching procedures, as suggested by Polydorou et al.(36,47) Since it has been suggested that roughening is a result of erosion of the matrix, the consequent debonding of resin–filler interfaces would lead to dislodgment as to elution of fillers. [15,17] Thus, any difference in surface roughness is expected to occur in composites with higher resin content.(36) Besides that, it has been referred that composites matrices composed of bisphenol A-glycidyl methacrylate (Bis-GMA) and urethane dimethacrylate (UDMA) resin polymers, which are present in composition of Filtek Supreme XTE™, can be softened with similar solubility parameters.(16,36)

In regard to R_{sk}, the current study showed a statistically significant increase in Filtek Supreme XTE™ after being treated with carbamide peroxide at 10%. This phenomenon is explained by an increase in the predominance of peaks in their topography. Although each specimen was rinsed with distilled water in order to remove the bleaching agent completely, this result may be due to accumulation of residual components, presented in carbamide peroxide, on superficial surface of specimens during 14 days of treatment.

In future investigations, it will be relevant to brush the specimens after the end of each application of bleaching agent to ensure that it is completely removed.

It is important to refer that in vitro studies are limited in their attempt to simulate clinical conditions.(15) In this study, the bleaching agents were not diluted or buffered with any water content such as saliva or distilled water during bleaching treatments, as in other studies.(16,25,30) Storage of composite specimens in artificial saliva between incubation with the bleaching material was done to simulate the clinical situation.(3,10,54) The artificial saliva was renewed every day in order to minimize the effect on the monomers' leaching of the composite materials on their surface.(36) For the purpose of standardization, this intermittent storage was performed with artificial saliva instead of human saliva in the present study.(10) Storage in natural saliva may modify or attenuate the effect of peroxides by formation of a surface-protection salivary layer on the restorative material.(12)

It must be emphasized that this study is in vitro and specimens were stored in artificial saliva, without any influence of bacterial flora present in clinical situations. An increase in surface roughness is not only associated with plaque retention, but also makes it difficult to be removed by mechanical procedures, which may lead to gingival inflammation and caries formation.(25,51,54) It was reported by Mor et al that bleaching agents may affect adherence of certain cariogenic microorganisms to the outer surfaces of composite resin restorations.(59) In this context it should be mentioned that salivary proteins absorbed on to the surface of composite materials decreased after bleaching with peroxide containing agents, which is suggested to have an influence on bacterial adhesion of cariogenic bacteria, such as *Streptococcus sobrinus* and *Streptococcus mutans*, but not of *Actinomyces viscosus.*(12)

Therefore, considering that bleaching is widely applied in approaches to improve dental aesthetics(60), it will relevant to test the effects of microhardness and roughness of resin composites in clinical trials.

Conclusions

Within the limitations of this study, it can be concluded that:

1. The microhardness of Filtek Supreme XTE™ and SonicFill™ is not affected by bleaching treatments.
2. Both bleaching treatments evaluated increase R_z parameter in Filtek Supreme XTE™ groups, in contrast to the SonicFill™ groups.
3. The carbamide peroxide 10% treatment affects the R_{sk} in Filtek Supreme XTE™ group with no significant effect in SonicFill™ group.

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Annexes

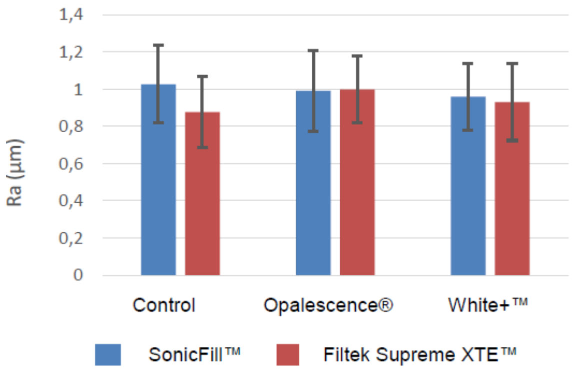

Figure 1: Roughness average (R_a) of all tested materials.

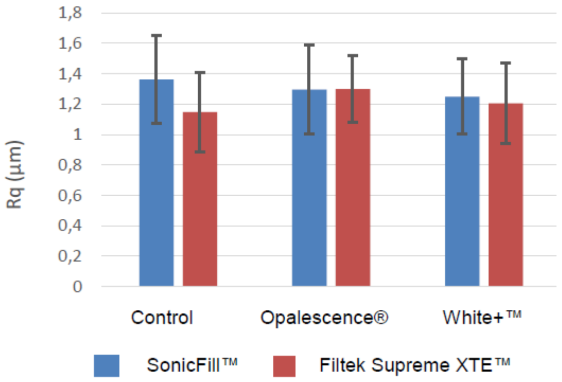

Figure 2: Root mean square roughness (R_q) of all tested materials.

Table I: Statistical results obtained with groups 1, 3 and 5.

	Group	Mean Difference (I-J)	Std. Error	Significance		95% Confidence Interval			
						Tukey		Bonferroni	
				Tukey	Bonferroni	L. Bound	U. Bound	L. Bound	U. Bound
R_a	1 and 3	0.0361750	0.0641411	0.840	1.000	-0.118175	0.190525	-0.122041	0.194391
	1 and 5	0.0666650	0.0641411	0.555	0.909	-0.087685	0.221015	-0.091551	0.224881
	3 and 5	0.0304900	0.0641411	0.883	1.000	-0.123860	0.184840	-0.127726	0.188706
R_q	1 and 3	0.0659500	0.0874473	0.732	1.000	-0.144485	0.276385	-0.149755	0.281655
	1 and 5	0.1120000	0.0874473	0.412	0.616	-0.098435	0.322435	-0.103705	0.327705
	3 and 5	0.0460500	0.0874473	0.859	1.000	-0.164385	0.256485	-0.169655	0.261755
R_z	1 and 3	0.0135550	0.2439354	0.998	1.000	-0.573455	0.600565	-0.588157	0.615267
	1 and 5	-0.2150700	0.2439354	0.654	1.000	-0.802080	0.371940	-0.816782	0.386642
	3 and 5	-0.2286250	0.2439354	0.619	1.000	-0.815635	0.358385	-0.830337	0.373087
R_{sk}	1 and 3	0.1425000	0.1596456	0.647	1.000	-0.241674	0.526674	-0.251296	0.536296
	1 and 5	0.1709050	0.1596456	0.536	0.867	-0.213269	0.555079	-0.222891	0.564701
	3 and 5	0.0284050	0.1596456	0.983	1.000	-0.355769	0.412579	-0.365391	0.422201
HV0.2	1 and 3	0.9000000	0.5760500	0.270	0.371	-0.486200	2.286200	-0.520900	2.320900
	1 and 5	-1.1900000	0.5760500	0.106	0.130	-2.576200	0.196200	-2.610900	0.230900
	3 and 5	-2.0900000	0.5760500	0.002	0.002	-3.476200	-0.703800	-3.510900	-0.669100

Table II: Statistical results obtained with groups 2, 4 and 6.

	Group	Mean Difference (I-J)	Std. Error	Significance		95% Confidence Interval			
						Tukey		Bonferroni	
				Tukey	Bonferroni	L. Bound	U. Bound	L. Bound	U. Bound
R_a	2 and 4	-0.1206250	0.0657246	0.168	0.217	-0.279192	0.037942	-0.283221	0.041971
	2 and 6	-0.0527850	0.0657246	0.703	1.000	-0.211352	0.105782	-0.215381	0.109811
	4 and 6	0.0678400	0.0608491	0.509	0.810	-0.078964	0.214644	-0.082695	0.218375
R_q	2 and 4	-0.1527217	0.0847955	0.179	0.232	-0.357299	0.051855	-0.362497	0.057054
	2 and 6	-0.0563467	0.0847955	0.785	1.000	-0.260924	0.148230	-0.266122	0.153429
	4 and 6	0.0963750	0.0785053	0.442	0.675	-0.093027	0.285777	-0.097839	0.290589
R_z	2 and 4	-0.5737900	0.2045747	0.019	0.021	-1.067346	-0.080234	-1.079887	-0.067693
	2 and 6	-0.7773850	0.2045747	0.001	0.001	-1.270941	-0.283829	-1.283482	-0.271288
	4 and 6	-0.2035950	0.1893994	0.534	0.862	-0.660539	0.253349	-0.672150	0.264960
R_{sk}	2 and 4	-0.5117833	0.1890181	0.024	0.027	-0.967808	-0.055759	-0.979395	-0.044172
	2 and 6	0.0004767	0.1890181	1.000	1.000	-0.455548	0.456501	-0.467135	0.468088
	4 and 6	0.5122600	0.1749968	0.014	0.015	0.090064	0.934456	0.079336	0.945184
HV0.2	2 and 4	-0.6783300	1.0902300	0.809	1.000	-3.308600	1.951900	-3.375400	2.018800
	2 and 6	-2.2933300	1.0902300	0.099	0.121	-4.923600	0.336900	-4.990400	0.403800
	4 and 6	-1.6150000	1.0093600	0.255	0.347	-4.050200	0.820200	-4.112000	0.882000