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# Effect of in-Office Bleaching on the Surface Roughness of Different Composite Resins#

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**Research Article**

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**ABSTRACT**

***Objectives:*** The aim of this study is to investigate the effect of a high concentration hydrogen peroxide bleaching agent on the surface roughness of four different composite resins.

***Material and Methods:*** For this purpose, with the help of teflon molds, a total of 24 composite samples (10 x 4 mm) were prepared, with n = 6 for each composite group. The samples were placed in teflon molds in two layers of 2mm and covered by transparent mylar strips at the top and bottom surfaces. The material was compressed with finger pressure between 1mm thick glass plates. The tip of the light device was applied directly from the transparent tape surface for the polymerization of the samples. Polymerization of the samples was carried out using LED light device in each layer. After the samples were polished with finishing discs, they were kept at 37°C for 24 hours in the distilled water. Surface roughness values (Ra) of all samples were measured with a profilometer device. After the first measurements, a whitening agent containing 35% hydrogen peroxide was applied to the surfaces, and surface roughness measurements were repeated after this process. Data were analyzed statistically using analysis of variance (ANOVA) and Tukey tests.

***Results:*** Profilometric evaluations showed a small increase in the surface roughness of all samples with a bleaching agent. When the initial and treated measurements of the groups were compared, the difference between the measurements was found statistically insignificant.

***Conclusion:*** The office bleaching agent containing 35% hydrogen peroxide did not make any difference in the roughness of the nanohybrid and microhybrid composite resins.

***Keywords***: Hydrogen Peroxide, Surface, Composite, Bleaching, Roughness

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## Introduction

Today, with the increase in the aesthetic expectations of the patients, the demand for teeth whitening treatment has increased. This process effectively removes the discolorations on the teeth without damaging the tooth tissue.[1,2]

Different types of composites are recommended for the restoration of teeth. As a result of advances in filler technology, a new composite formulation has been created with the combination of submicron size (0.04 µm) particles and smaller particles (0.1 µm-1 µm). These materials are classified as "micro-hybrid" composites. The addition of smaller particles to microhybrid composites distinguishes them from conventional hybrid composites and provides better polishing and application.[3] However, although the physical properties of microhybrid composites are superior to traditional microfilled composites, their polishability is not as good as microfilled composites.[4] The latest versions of micro-hybrid composites are "nanohybrid" composite resins developed with nanofiller technology. Nanohybrid composites include a combination of nanometer-sized filler particles (0.005–0.01 µm) and conventional type filler particles. Nanohybrids can be classified as universal composite resins that truly carry the application and polishing properties of microfilled composites and the physical strength and abrasion resistance of traditional hybrid composites.[5]

Whitening treatment can be performed by the dentist using agents containing high concentration (25%-40%) hydrogen peroxide or carbamide peroxide, as well as hydrogen peroxide (HP) at a lower concentration (3-7%) or (6-20%) using carbamide peroxide (CP) agents, it is also applied at home by the patient under the control of the physician. Whitening treatment creates some changes in the natural tooth structure and the existing restorations in the mouth are also affected by this situation. There are many studies are evaluating the effects of different concentrations of bleaching agents on microleakage, bonding strength, adhesion, discoloration, surface hardness, and surface roughness of composite resins.[6-9]

Although it is thought that the bleaching process does not have macroscopically visible effects on composite resin restorations, the microscopic effects it creates may have negative consequences. It is known that rough surfaces cause bacterial involvement[10,11], staining of the restoration[12], and periodontal diseases.[13]

This study aims to investigate the effect of a high concentration hydrogen peroxide bleaching agent on the surface roughness of four different composite resins.

## Materials and Methods

In this study, A2 color micro-hybrid Filtek Z250 (3M ESPE, St. Paul, MN, USA), three different nanohybrid filled composite Tetric N-Ceram (Ivoclar Vivadent, Schaan, Liechtenstein), Clearfil Majesty Esthetics (Kuraray, Osaka, Japan), and Filtek Z550 (3M ESPE, St. Paul, MN, USA) were used. The details of the tested materials are shown in Table 1.

Composite disks (10 mm in diameter and 4 mm in thickness) were prepared by using teflon molds. The teflon molds were positioned on a transparent plastic matrix strip lying on a glass plate. The composite materials were placed in 2-mm increments. After inserting the materials into the Teflon mold, a transparent plastic matrix strip was put over them and a glass slide was secured to flatten the surface. Each sample was light cured for 40 s in two steps by using a light-emitting diode (LED) unit (Elipar Freelight 2, 3M ESPE, St. Paul, MN, ABD) at light intensity of 600 mW/cm2 from both upper and lower surfaces of the samples. The distance between the curing light tip and sample was standardized by using a 1-mm glass slide. All the samples were stored in neutral artificial saliva and kept in oven at 37°C. After 24 h, the samples were washed with distilled water and polished with medium, fine, and superfine aluminium oxide disks (Sof-Lex system- 3M ESPE, St. Paul, MN) on a slow-speed handpiece, in accordance with the manufacturer's instructions. After polishing, all the resin specimens were then stored in distilled water for 24 h at 37°C to ensure complete polymerization.

Surface roughness (Ra) measurements of the samples were carried out with a two-dimensional profilometer (Mitutoyo Surftest SJ-201P Surface Roughness Tester, Mitutoyo Corporation, Tokyo, Japan). The cut-off value of the device used is 0.8 mm and the measurement distance is 5 mm. After measuring in three different regions from each sample surface, the average of the measured values obtained was taken. Before measurement, the profilometer was calibrated with the help of a reference block with a Ra value of 3.05 µm. Then, the office bleaching agent 35% HP (H35 Total Blanc Office; Nova DFL, Rio de Janeiro, Brazil) was applied in two 15-minute sessions in accordance with the manufacturer's instructions. The surface roughness of the washed and dried samples was measured again with a profilometer device.

The data obtained from our study were loaded into the SPSS (22.0) program and the parametric test assumptions were fulfilled in the evaluation of the data (Kolmogorov - Smirnov), the Tukey test was used to find the groups that made a difference in the analysis of variance analysis when comparing the measurements obtained from more than two independent groups ($p<0.05$).

## Results

The micro-hybrid composite group showed higher surface roughness (RA) than other groups before and after bleaching treatment. Data for initial $R_a$ and after bleaching $R_a$, are presented in Table 2. It was observed that nanohybrid composites were smoother than microhybrid composite after exposure to higher-concentration hydrogen peroxides ($p< 0,05$). Roughness increased after bleaching in Tetric N Ceram and Filtek Z550 groups, but this increase was statistically not significant. While there was no change in the post-bleaching roughness values in the Filtek Z250 group, the roughness decreased in the Clearfil Majesty group, but it was statistically insignificant. When the before and after measurements of the groups were compared, the difference between the measurements was found to be insignificant ($p>0.05$) (Table 2).

Table 1. Materials used in this study

| Material | Type | Main composition | Manufacturer |
|---|---|---|---|
| Tetric N-Ceram | Nanohybrid composite resin | Matrix: Bis-GMA, Bis-EMA (6), UDMA, TEGDMA, Procrylat<br>Filler: Barium aluminium silicate glass(0.4µm,0.7µm), ytterbium trifluoride(200nm), mixed oxide(160nm), Prepolymer (0.7 nm)<br>Filler loading: 80 wt%, 55-57 vol% | Ivoclar Vivadent, Schaan, Liechtenstein |
| Clearfil Majesty Esthetics | Nanohybrid composite resin | Matrix: Bis-GMA, TEGDMA, hydrophobic aromatic dimethacrylate, hydrophobic aliphatic methacrylate,<br>Fillers: Silanated barium glass filler, prepolymerized organic filler (avarage particle size 0.7 µm)<br>Filler loading: 78 wt%, 66 vol% | Kuraray, Osaka, Japan |
| Filtek Z250 | Microhybrid composite resin | Matrix: BIS-GMA, BIS-EMA, UDMA with small amounts of TEGDMA 60 vol%<br>Fillers: Silanized zirconia/silica particles (size range: 0.01 to 3.5 microns, average size: 0.6micron)<br>Filler loading: 75-85 wt%, 60 vol% | 3M ESPE, St. Paul, MN, USA |
| Filtek Z550 | Nanohybrid composite resin | Bis-GMA, UDMA, Bis-EMA, TEGMA ve PEGDMA<br>Fillers: Surface-modified zirconia/silica fillers 3000 nm (3 µm or less), non-agglomerated/nonaggregated surface-modified silica particles 20 nm<br>Filler loading: 82 wt%, 68 vol% | 3M ESPE, St. Paul, MN, USA |
| Total Blanc Office H35 | 35% hydrogen peroxide | 35% hydrogen peroxide, 2% sodium fluoride and 5% potassium nitrate | Total Blanc Office H35, Nova DFL, Rio de Janeiro, Brazil |

Table 2. Means and standard deviations (SDs) of the Ra values (µm) for all materials tested

| Composites | Initial Ra mean ± SD | Final Ra mean ± SD | |
|---|---|---|---|
| Tetric N Ceram | 0.21 ± 0.03 | 0.23 ± 0.02 | p=0.115 |
| Clearfil majesty esthetic | 0.30 ± 0.09 | 0.23 ± 0.05 | p=0.098 |
| Filtek Z250 | 0.33 ± 0.06 | 0.33 ± 0.06 | p=0.296 |
| Filtek Z550 | 0.22 ± 0.04 | 0.24 ± 0.03 | p=0.206 |

## Discussion

The purpose of this in vitro study was to evaluate the effect of an office bleaching agents on the surface roughness of four different composite resins which have different compositions. Frequently, in daily clinical practice, composite resin restorations exist in teeth that are planned to be bleached. Although the effects of bleaching agents on teeth are known, their effects on restorative materials in vitro are controversial.[14] To evaluate this effect on the surface of composites, different techniques have been used, such as scanning electron microscopy[15] and profilometer.[16] In many research, it has been reported that SEM procedures changed the natural conditions or part of the specimen structure, and the resolution and magnification of the SEM affected the results.[17] That's why we chose to use a profilometer device in our study.

Some studies have shown that in-office bleaching has a detrimental effect on composite surface roughness.[18-20] On the other hand, some researchers reported that there was not any detrimental effect on the surface roughness of composites.[21-23] Different results were also evident regarding the use of lower concentration office bleaching agents. In this study, the results demonstrated that the Ra parameter did not change significantly after bleaching.

All samples were finished and polished before bleaching to simulate clinical conditions. Finishing refers to gross contouring or reducing of the restoration to obtain the desired anatomy, and polishing reduces the roughness and scratches created by finishing instruments.[24] According to the manufacturer's instructions for using Sof-Lex discs, ‘‘a dry surface will produce a smoother, more uniform finish’’.[25] However, working without water cooling can cause an increase in temperature and burns on the restoration surface. Therefore, samples were subjected to finishing and polishing using the Sof-Lex system on a water-cooled, low speed handpiece. Surface irregularities that we see in the microscope examination before bleaching may be caused by the Sof-Lex system. Similar views have been observed in a previous study where wet polishing with Sof-Lex disks had led to a rougher surface than dry polishing.[26]

Resin-containing materials soften and roughen their surfaces when exposed to acid-containing chemicals, and as a result, they become more sensitive to physical forces.[27,28] While hydrogen peroxide is a powerful oxidizer, it is also extremely acidic.[29] On the mechanism of hydrogen peroxide decomposition, as hydrogen peroxide reacts with a tooth, it decomposes into hydroxyl radicals or water and oxygen molecules.[24,30] HP and released free radicals could react with the composites' organic polymer matrix as well as inorganic structures, eventually dissolving the surface by extracting the mineral elements.[30,31] Yu *et al.*[32], in a study examining the effect of a high concentration of hydrogen peroxide on the surface roughness of composites, found that the roughness of micro-hybrid and nanohybrid composites increased after bleaching compared to the control group, but this increase was statistically insignificant. Similarly, in our study, although minimal changes were observed in the surface roughness of both micro-hybrid composite and nanohybrid composites after bleaching, they were statistically insignificant. When the surface roughness data before and after bleaching was evaluated, no difference was found between micro-hybrid and nanohybrid composites.

The differences in the composite resins’ roughness values obtained after the same bleaching regime may be related to the different polymers in their organic phases, and their filler content and particle size.[27] The organic matrix contents of the composites used in this study were approximately similar. However, while all composite samples contain bisphenol-A dimethacrylate (BIS-GMA) and urethane dimethacrylate (UDMA), Clearfill Majesty Esthetics does not contain UDMA. Regarding the organic composition of the composites, Dogan *et al.*[25] also observed that the composite containing the dental resin monomers UDMA in its matrix is more degraded compared to the composite containing bisphenol A Bis-GMA. Similarly, in this study, the surface roughness of the samples containing UDMA was more affected.

The filler load is directly related to the surface area that is taken up by filler particles versus the resin matrix, as the surface smoothness is generally determined by the largest inorganic particles present within the composite.[13] When the data obtained from our study were examined, the microhybrid composite Z250 with the largest particle size (average particle size 0.6 µm) showed the highest roughness values before and after bleaching among the groups, but the rate of change in surface roughness was statistically similar to nanohybrid composite groups.

It has been claimed that roughening is a result of erosion of the matrix, the consequent debonding of resin–filler interfaces would lead to dislodgment and also to elution of fillers.[33] Thus, any difference in surface roughness is expected to occur in composites with higher resin content.[34] The total content of inorganic fillers in our composite samples Clearfil Majesty Esthetics (78% by weight) is lower than in Tetric N-Ceram (80% wt), Filtek

Z250 (83.5% by weight), Filtek Z550 (%82) and might be another reason that this material is more susceptible to alteration during bleaching procedures, as reported by Polydorou *et al.*[34]

Concerning the structure of inorganic fillers in the resin composite, it has been reported that barium-containing glass fillers are more susceptible to water attacks than both quartz and fairly purified amorphous $SiO_2$. The microfill particles, on the other hand, have more Si available for leaching due to their greater total surface area.[35] Finer glass particles have also been observed to dissolve faster than coarser glass particles. More interfaces are created as a result of the dissolving, which can affect filler degradation.[36] A silica-filled composite may be said to degrade faster from a clinical perspective.

Varanda *et al.*[37], observed that 35% hydrogen peroxide increased the surface roughness of microhybrid composite samples but Doğan *et al.*[25] found that surface roughness decreased in their studies using microhybrid composites. The differences between the results of these studies[25,37] in which AFM was used, are associated with the methodological approach. Varanda *et al.* evaluated the same area in the same sample before (control) and after the use of bleaching agents, but Dogan *et al.* evaluated the different areas to analyze the changes. Whereas the other researchers[38,39] claimed that 35% hydrogen peroxide doesn't affect microhybrid composites. Similarly, in this study, no change was observed in the surface roughness of Filtek Z250.

The critical surface roughness threshold for bacterial adhesion has been identified at 0.2 µm.[13] While no reduction in bacterial accumulation is expected below this threshold, any increase in surface roughness above 0.2 µm results in a simultaneous increase in plaque accumulation, as well as the risk of caries and periodontal inflammation, because of the restoration's esthetics and longevity are all at risk. In addition, Kim *et al.*[8] stated that Ra values less than 0.3 µm after bleaching were clinically acceptable. In this study, the initial and finishing Ra values of the composites were measured between 0.21 µm and 0.33 µm, close to the critical limits.

Main faults in matrices such as pits, pores, and weaknesses equate with the degree of damage. Furthermore, the degree of conversion of the resin matrix and the chemical composition of the matrix can affect this process. The degradation process can also be influenced by powers on the radical formation of bleaching materials and their PH alongside their contact time.[20,40] The effect of each prescribed reason can affect the results of different studies. Surface roughness can also be affected by many factors. In this study which we examined the effect of 35% hydrogen peroxide on micro-hybrid and nanohybrid composites, although there were differences in the measurements after bleaching, these differences were found to be statistically insignificant. To assess the long-term effectiveness of the restorative materials following aesthetics treatments utilizing bleaching chemicals, longitudinal clinical investigations and clinical follow-up evaluations should be done.

## Conclusions

Microhybrid composites have rougher surfaces than nanohybrid composites. Although the office bleach containing 35% hydrogen peroxide produced minor changes in the roughness of nanohybrid and microhybrid composite resins, this change is not statiscally significant.

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## Conflicts of Interest Statement

Conflict of interest: The authors do not have any financial interest in the companies whose materials are included in this article.

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