

## THE EFFECT OF LASER-ASSISTED IN-OFFICE BLEACHING ON SURFACE ROUGHNESS OF DIFFERENT TYPES OF RESTORATIVE RESINS

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### ABSTRACT

**Background and Aim:** The aim of this study was to evaluate the effects of laser-assisted in-office bleaching on the surface roughness of three types of resin composite materials.

**Materials and Methods:** Three types of resin composites (Ceram-X Mono, Filtek Silorane, Tetric EvoCeram Bulk Fill) were used for the study. A total number of ten samples measuring 9mm in diameter X 2mm thick were prepared from each one of the restorative materials. The samples were bleached with 35% hydrogen peroxide gel (LaserWhite20) with diode laser (Epic, 940nm) at 7 Watts in continuous mode. The roughness of the specimens (Ra,  $\mu\text{m}$ ) was measured before and immediately after the bleaching procedure using a surface profilometer. Data were analyzed using Kruskal-Wallis and Wilcoxon tests.

**Results:** There were no significant differences in roughness values among the groups before the bleaching procedures ( $p > 0.05$ ). After bleaching, significant differences were observed between Ceram-X Mono and Tetric EvoCeram Bulk Fill ( $p < 0.05$ ).

Laser-assisted in-office bleaching significantly increased only the surface roughness of Ceram-X Mono ( $p < 0.05$ ). The results showed no difference in Ra values of Filtek Silorane and Tetric EvoCeram Bulk Fill after bleaching ( $p > 0.05$ ).

**Conclusion:** An increase in surface roughness was reported only in nanoceramic resin composite, Ceram-X Mono following bleaching. The effect of laser-assisted in-office bleaching on surface roughness was found to be material dependent.

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## LAZERLE YAPILAN OFİS TİPİ BEYAZLATMANIN FARKLI TÜRDEKİ RESTORATİF REZİNLERİN YÜZEY PÜRÜZLÜLÜĞÜNE ETKİSİ

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### ÖZ

**Amaç:** Bu çalışmanın amacı lazerle yapılan ofis tipi beyazlatmanın üç farklı türdeki kompozit rezinlerin yüzey pürüzlülüğüne etkisini değerlendirmektir.

**Gereç ve Yöntem:** Bu çalışmada üç tür kompozit rezin (Ceram-X Mono, Filtek Silorane, Tetric EvoCeram Bulk Fill) kullanıldı. Her restoratif materyalden on adet 9mm çapında 2mm kalınlığında örnekler hazırlandı. Örnekler, %35'lik hidrojen peroksit jel (LaserWhite 20) ile 7 Watt gücünde sürekli moddaki diyet lazer (Epic, 940nm) kullanılarak beyazlatma işlemine tabi tutuldu. Örneklerin pürüzlülüğü (Ra, µm) beyazlatma işlemi öncesi ve sonrasında yüzey profilometresi ile ölçüldü. Elde edilen veriler Kruskal-Wallis ve Wilcoxon testleri ile analiz edildi.

**Bulgular:** Beyazlatma işlemi öncesinde grupların pürüzlülük değerleri arasında anlamlı bir farka rastlanılmamıştır ( $p>0.05$ ). Beyazlatma sonrasında ise Ceram-X Mono ve Tetric EvoCeram Bulk Fill arasındaki fark istatistiksel olarak anlamlı bulunmuştur ( $p<0.05$ ).

Lazerle yapılan beyazlatma sadece Ceram-X Mono örneklerinin yüzey pürüzlülüğünü anlamlı olarak artırmıştır ( $p<0.05$ ). Beyazlatma sonrasında Filtek Silorane ile Tetric EvoCeram Bulk Fill'in pürüzlülük değerleri arasında anlamlı bir fark görülmemiştir ( $p>0.05$ ).

**Sonuç:** Beyazlatma sonrasında sadece nanoseramik kompozit olan Ceram-X mono örneklerinin yüzey pürüzlülüğünde artış görülmüştür. Lazerle yapılan ofis tipi beyazlatmanın yüzey pürüzlülüğüne etkisi materyale göre değişim göstermektedir.

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## INTRODUCTION

The increased patient demands, awareness of and interest in having more esthetic and whiter teeth has lead to increased usage of tooth bleaching. The most conservative method to enhance esthetics and achieve white smile is tooth-bleaching. Traditional home bleaching methods are increasingly being replaced by in-office (power) bleaching because of the desire for immediate whitening.<sup>1,2</sup> With in-office bleaching the color change can be observed in single visit. In in-office bleaching, high concentration of hydrogen peroxide is used with the light activation devices such as light-emitting diodes and diode lasers.<sup>3,4</sup> The most frequent adverse effect of tooth bleaching is sensitivity. A major advantage of laser-assisted in-office bleaching is that it minimizes hypersensitivity and secondly, helps the release of the free radicals in the bleaching gel for a faster whitening procedure.<sup>5</sup>

In recent years, dental composites have become popular as restorative materials for premolar and molar teeth. Despite the improvements in the formulations of composite resins, one of the most important shortcomings of dental composite is polymerization shrinkage, which leads to reduced mechanical properties.

Siloranes have been suggested due to their hydrophobicity and low polymerization shrinkage.<sup>6</sup> The silorane matrix is formed by a cationic ring opening of the silorane monomers during polymerization instead of free radical polymerization.<sup>7</sup> The siloxane backbone was introduced in order to provide a most hydrophobic nature, which is very important since too high water sorption and solubility limits the long-term intraoral physical properties of the composite.<sup>8</sup>

Nanoceramic resin composite comprises organically modified ceramic nanoparticles and nanofillers that are combined with conventional glass fillers of  $\sim 1\mu\text{m}$ . Unlike conventional polymers, ormocers have an inorganic backbone based on silicon dioxide and are functionalized with polymerizable organic units to produce three-dimensional compound polymers.<sup>9</sup> Nanoparticles, have many advantages, including reduced polymerization shrinkage, increased mechanical properties, and better gloss retention.<sup>10-12</sup>

Both of these composites should be placed with incrementally 2-mm thicknesses, which might be time-consuming for the dentist. There is also an associated increased risk of forming air bubbles or causing moisture contamination between the increments that may lead to failures.<sup>13,14</sup> To overcome these shortcomings, recently a

new type of resin composite, bulk fill resin composite, has been marketed. It is an attempt to speed up the restoration process by enabling up to 4mm thick increments to be cured in one step.<sup>15-17</sup> The use of thicker increments in bulk-fill resin composites is both due to the developments in photoinitiator dynamics and their increased translucency, which allows additional light penetration and a deeper cure.<sup>14,18,19</sup>

Surface roughness of a restoration is one of the important factors that determine the long-term success of a restoration.<sup>20</sup> A restoration with a rough surface would have more plaque accumulation and stain retention, thereby result in gingival inflammation, secondary caries and poor esthetic characteristics.<sup>21</sup> During bleaching procedure, bleaching agent could accidentally touch to restorations. Even though the effect of bleaching on surface roughness of resin composites has been widely reported in the literature<sup>22-25</sup>, there is inadequate information about the laser-assisted in-office bleaching effects on surface roughness of newly developed resin composites.

This in vitro study evaluated the effects of diode laser-assisted bleaching on surface roughness of different types of resin restoratives. The null hypothesis tested was that laser-assisted in-office bleaching would not affect the surface roughness regardless of the type of resin composite materials.

## MATERIALS AND METHODS

The three commercial restorative resin composites used in this study are listed in Table I. A circular polyethylene mold (9 mm in diameter, 2 mm thick) was used to fabricate each of the specimens. Molds were positioned over Mylar strips (Hawe-Neos Dental, Bioggio, Switzerland) and placed onto a glass microscope slide. After each resin composite was inserted into mold in one increment of 2mm, another Mylar strip/glass slide was placed over the composites and pressure was applied, causing the excess material extrude. The curing tip of a LED light (SDI, Radii Plus, Ireland, Dublin) was held against the top of slide and cured for 20 seconds. The power density of the light source was verified using a hand-held dental curing radiometer (Dentsply/Caulk, Milford, DE, USA) and the irradiance of the light was  $1500\text{ mW/cm}^2$ . The polymerized specimens were removed from the mold and stored in distilled water at  $37^\circ\text{C}$  for 1 month. Ten disc-shaped specimens of each resin composite were prepared. Prior to the roughness measurement, the specimens were polished flat using a sequence of 400-800-1200-grit

Table I. Materials used in the study

| Product Name               | Type                        | Manufacturer/Batch #                              | Composition                                                                                                                                           | Average Filler Size                                               | Filler content (weight/<br>volume)        |
|----------------------------|-----------------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------|
| Ceram-X Mono               | Nanoceramic resin composite | Dentsply Caulk, Milford, DE, USA<br>1007002013    | Methacrylate modified polysiloxane, dimethacrylate resin, barium-aluminum-borosilicate glass, methacrylate functionalized silicon dioxide nanofillers | Glass filler: 1.1-1.5 $\mu\text{m}$<br>Nanofillers: 2.3 and 10 nm | 76 / 57                                   |
| Filtek Silorane            | Microhybrid resin composite | 3M ESPE, Seefeld-Germany<br>N 132573              | 3,4-epoxycyclohexylethylcyclopolymethylsiloxane, bis-3,4-epoxycyclohexylethyl-phenyl/methylsilane silanized quartz, yttrium fluoride                  | 0.1-2.0 $\mu\text{m}$                                             | 76 / 55                                   |
| Tetric Evo Ceram Bulk Fill | Nanohybrid resin composite  | Ivoclar Vivadent, Schaan, Liechtenstein<br>P84129 | Bis-GMA, UDMA, Ba-Al-Si glass, prepolymer filler (monomer, glass filler, and ytterbium fluoride), spherical mixed oxide                               | 0.4-0.7 $\mu\text{m}$                                             | 79-81 (including 17% prepolymers) / 60-61 |

silicone carbide paper and aluminum oxide discs (Sof-Lex, 3M, ESPE, MN, USA). To reduce variability, a single operator carried out specimen's preparation, finishing and polishing procedures. After the completion of polishing procedures, the specimens were rinsed with tap water and then cleaned in an ultrasonic cleaner for 2 minutes and air-dried.

To measure the surface roughness of the specimens a contact profilometer (Mitutoyo SurfTest-402 Surface Roughness Tester, Mitutoyo Corp., Tokyo, Japan) was used. Three profilometer tracings were made near the center of each specimen, and average was determined. The average surface roughness (Ra) of the baseline specimens was measured by one operator to minimize variation.

After baseline measurements, the specimens were subjected to diode laser-assisted in-office bleaching. The laser-bleaching agent used in the study was LaserWhite20 (35% hydrogen peroxide gel, Ingbert, Germany). The bleaching gel was applied in about 1mm thick on the surface of prepared specimen and then evenly spread with the brushed applicator tip. The Diode laser, Epic with a wavelength of 940nm (Biolase Technology Inc. San Clemente, CA, USA) was used at 7 Watts with a total energy of 200 J in continuous mode. The whitening handpiece of the laser was placed in close proximity to specimen without contacting the gel. After application of the laser one more time, the gel was remained on the specimens for 5 minutes. The bleaching gel was then removed using gauze and then rinsed with water spray to remove any residual gel. LaserWhite20 bleaching gel was reapplied and activated by laser. At the end of the procedure, gel was removed and rinsed thoroughly with water. The roughness of samples was re-measured as previously described.

As the average roughness values were not normally distributed (Shapiro-Wilk test), a non-parametric Kruskal-Wallis Multiple Comparisons test was applied to assess significant differences among the groups. Wilcoxon test was applied for comparisons within each group. All statistical analysis was carried out at significance level 0.05.

## RESULTS

Mean and standard deviations of surface roughness (Ra,  $\mu\text{m}$ ) is presented in Table II. There was no statistically significant difference in surface roughness amongst the tested resin composites before bleaching ( $p=0.067$ ). After bleaching, significant differences were observed between the roughness values of Ceram-X Mono and TetricEvoCeram Bulk Fill ( $p=0.03$ ).

**Table II.** Median (min-max) surface roughness values (Ra,  $\mu\text{m}$ ) and interquartile range (IqR) for each restorative resin

| Restorative resins        | Before Bleaching     |             |      | After Bleaching        |             |      |
|---------------------------|----------------------|-------------|------|------------------------|-------------|------|
|                           | Median               | Min-Max     | IqR  | Median                 | Min-Max     | IqR  |
| Ceram-X Mono              | 0.325 <sup>a,A</sup> | (0.17-0.88) | 0.24 | 0.396 <sup>b,B</sup>   | (0.21-0.86) | 0.30 |
| Filtek Silorane           | 0.214 <sup>a,C</sup> | (0.12-0.85) | 0.36 | 0.236 <sup>b,C,C</sup> | (0.12-0.85) | 0.31 |
| Tetric EvoCeram Bulk Fill | 0.157 <sup>a,D</sup> | (0.11-0.66) | 0.32 | 0.162 <sup>c,D</sup>   | (0.09-0.60) | 0.15 |

Within each column groups identified by different superscript lower case letters indicate significant difference ( $p < 0.05$ ). While Kruskal-Wallis test revealed no significant difference between the groups before bleaching ( $p = 0.067$ ), significant differences were observed after bleaching ( $p = 0.036$ ).

Within each row, different superscript capital letters indicate significant difference ( $p < 0.05$ ). Wilcoxon test showed significant differences only in Ceram-X Mono group ( $p = 0.06$ ).

Laser-assisted in-office bleaching affected only the surface roughness of Ceram-X Mono and significantly increased roughness compared to baseline ( $p = 0.006$ ). No significant difference in surface roughness from baseline was determined for Filtek Silorane ( $p = 0.182$ ) and TetricEvoCeram Bulk Fill ( $p = 0.583$ ) with the bleaching.

## DISCUSSION

In the present study, the surface roughness of three resin composite restorative materials was investigated after diode laser-assisted in-office bleaching. Patients that have teeth with restorations might receive dental bleaching treatments. Since bleaching can affect the physical and mechanical properties of dental tissues and restorative materials, it is worth to evaluate the effects of bleaching agents. In most of the previous studies, the effects of home and office bleaching have been investigated.<sup>23,26-29</sup> However there is only limited data about the effect of diode laser bleaching. Moreover, most of the studies evaluated the effects on tooth structure.<sup>30-32</sup> To the knowledge of authors, there is no study that investigated the effects of diode laser bleaching on surface roughness of a recently introduced bulk fill resin composite, Tetric EvoCeram Bulk Fill.

In a study evaluating the effects of home bleaching on surface roughness of restorative materials, there was an increase in surface roughness for some materials, while other tested materials displayed decrease in roughness values.<sup>26</sup> Similar results were obtained by Wattanapayungkul et al.<sup>23</sup>, who concluded that the effect of bleaching on surface roughness was material- and time-dependent. In another study evaluating high concentration carbamide peroxide containing home bleaching systems on roughness of two

composite resins by SEM, no considerable changes after bleaching were observed.<sup>27</sup> Zuryati et al.<sup>28</sup>, evaluated the effects of 10% and 20% Opalescence PF home bleaching agents on the surface roughness and hardness of universal nanocomposite, Filtek Z350, anterior nanocomposite, KeLFil, and nanohybrid composite, TPH. Although the surface hardness for KeLFil and TPH 3 were significantly reduced, no adverse effects on the surface roughness of all three composite resins were detected. Moreover, the AFM evaluation of surface roughness showed that both bleaching agents yielded Ra values below 200nm for all materials tested, which poses no risk of the accumulation of plaque.

In another study<sup>33</sup> the bleaching treatment with 10% and 35% hydrogen peroxide showed no significant changes in surface roughness of nanohybrid and nanocomposites, Z350 and TPH3, which agrees with de Silva et al.<sup>24</sup>, and Duschner et al.<sup>34</sup>

Home versus in-office bleaching systems' effect on 3D surface profile of tooth colored restorative materials was evaluated in a recent study.<sup>29</sup> Nanohybrid resin composite, microhybrid resin composite and nanoionomer cement bleached with Opalescence PF (20% carbamide peroxide) or Opalescence Boost (40% hydrogen peroxide) bleaching agents resulted in the same 3D surface roughness. Concur with the results of the mentioned above studies, laser bleaching did not change the roughness values of microhybrid resin composite, Filtek Silorane and nanohybrid resin composite, Tetric EvoCeram Bulk Fill in the present study. However, the bleaching agents used in most of the mentioned studies were mostly home bleaching products with low carbamide peroxide concentrations. Therefore it

might not be accurate to directly compare our results with them.

An important factor in determining the surface roughness is the intrinsic roughness of a composite material, which is determined by the size, shape, and quantity of the filler particles.<sup>35</sup> Materials with larger filler particles are expected to have higher Ra values after finishing/polishing since harder filler particles are generally left protruding from the surface during finishing and polishing. Filtek Silorane contains quartz and yttrium fluoride as filler particles. Its average particle size is 0.1-2 micrometer and the filler volume is 55% according to the manufacturer's information. In a recent study it was found that the silorane-based composite resin results showed lower roughness values than methacrylate-based resins.<sup>36</sup> The nanohybrid composite Tetric EvoCeram Bulk Fill contains Ba-Al-Si glass and prepolymer fillers with a particle size of 40 to 3000nm. However its filler volume is quite higher (60%) than the other tested restoratives.

In the present study, bleaching only caused an increase in surface roughness of the nanoceramic restorative material, Ceram-X Mono. Ceram-X Mono contains organically modified ceramic nanoparticles and nanofillers combined with conventional glass particles of approximately 1-1.5  $\mu\text{m}$ . Because of its composition, it might have behaved in a different fashion to the bleaching treatment. Although its filler volume (57%) was similar, in Filtek Silorane the filler size was higher than other restorative materials.

Contrary to our findings, the in-office bleaching with 35% hydrogen peroxide-based gel was found to increase the surface roughness of microfilled, microhybrid, and nanofilled resins, significantly.<sup>37</sup> However, in that study atomic force microscopy was used to evaluate the roughness. The diversity might be related with the used methodology. De Andrade et al.<sup>25</sup> investigated the effects of three bleaching gels 10% carbamide peroxide or 16% or 35% hydrogen peroxide and staining solutions on roughness and shade changes in a nanofilled resin composite, Filtek Supreme. It was found that Filtek Supreme presented higher roughness after bleaching and staining. Similar results were obtained by Gurgan and Cakir<sup>38</sup>, who found that the bleaching regimens (10% carbamide peroxide and 6.5% hydrogen peroxide strip bands) increased the surface roughness of an ormocer (Definite), a packable composite (Filtek P60) and a flowable composite (Filtek Flow).

In some SEM studies and profilometric analyses, it was shown that 10-16% carbamide peroxide bleaching gels

may lead to a slight, but statistically significant, increase in surface roughness and numbers of porosities of microfilled and hybrid composite resins.<sup>39,40</sup>

Wang et al.<sup>41</sup> evaluated the effects of three different bleaching agents; 35% hydrogen peroxide Whiteness HP, 35% Whiteness HP MAXX and 16% carbamide peroxide Whiteness Standard on surface roughness of Filtek Supreme, Filtek Z350, Grandio, Opallis and Filtek Z250 microhybrid composite. They also concluded that the changes in surface roughness of resin composites after bleaching were material- and time-dependent. The bleaching gels affected nanofilled and microhybrid resin composite.

Although there are many roughness parameters, arithmetic mean roughness is by far the most commonly used. Each roughness parameter is calculated using a formula to describe the surface. Arithmetic mean roughness (Ra) is the arithmetic average of all frames of the profile filtered by measuring the length from the line of the reference profile.<sup>42</sup> This is why we decided to use Ra value.

In the present study Ra values of Tetric EvoCeram Bulk Fill after bleaching were generally smaller than the critical threshold surface roughness for bacteria adhesion of 0.2  $\mu\text{m}$ .<sup>22</sup> On the other hand, all tested restorative resins' Ra value were lower than 1  $\mu\text{m}$ , which was reported as this value makes the surface visibly smooth.<sup>43</sup> A clinical study determined a threshold of detection value for surface roughness of restorations by patients using their tongue. It was concluded that the surface of restorations should have a maximum roughness 0.50  $\mu\text{m}$  in order not to be detected by the patient.<sup>44</sup> In the present study all tested restorative materials' roughness values even after bleaching were below this value.

Due to the rougher surface obtained in Ceram-X Mono after laser bleaching, the null hypothesis tested was rejected. It is important to exercise a great caution during bleaching gel application and should be avoided to touch adjacent restoration.

As the pH value is an important factor for the rate of reaction in the bleaching process, further studies should be conducted with different bleaching systems with different concentrations. On the other hand, it is also noteworthy that specimens were stored in distilled water instead of saliva. As saliva acts as a protective barrier, adverse affects might have been reduced. Therefore additional studies are needed to confirm the results obtained in the present study.

## CONCLUSION

Diode laser-assisted bleaching caused an increase in surface roughness of nanoceramic resin composite, Ceram-X Mono. The effect of laser-assisted in-office bleaching on surface roughness differs according to the type of resin composite.

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