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Original research

# The effects of different repolishing procedures on the color change of bulk-fill resin composites

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**Purpose**

The purpose of the study was to investigate the impact of repolishing procedures on the color change of bulk-fill resin composites after being exposed to coffee.

**Materials and Methods**

Four bulk-fill resin composites (Filtek One bulk-fill, Tetric EvoCeram bulk-fill, Admira Fusion x-tra bulk-fill, Grandio SO x-tra bulk-fill) were tested. Sixty samples were prepared with each resin composite and were randomly divided into two groups: first one received the one-step polishing system (Optragloss) and the other group received the two-step polishing system (Nova Twist) (n=30). After being kept in coffee for 12 days, the samples were divided into three subgroups according to repolishing: one-step repolishing group, two-step repolishing group, and non-repolishing group (n=10 for each). Color measurements of the resin composite samples were determined with a spectrophotometer. The difference in color change was calculated using the CIEDE 2000 color formula. The data were analyzed using three-way ANOVA and Tukey test.

**Results**

Among composite materials, Filtek One bulk-fill (1.84 ± 0.98) less color change was observed compared to others (p<0.001). In terms of polishing systems, Optragloss (2.96 ± 1.51) showed significantly greater color change than Nova Twist (2.21 ± 1.07) (p<0.001). The non-repolishing group (3.78 ± 1.25) presented significantly greater color change than the Nova Twist sytem (1.49 ± 0.61) and Optragloss system (2.50 ± 1.01) (p<0.001).

**Conclusion**

The repolishing process reduced discoloration. A two-step repolishing system results in less color change compared to a one-step repolishing application. In polishing systems containing diamond particles, increasing the number of steps can contribute to color stability.

***Keywords:*** *Bulk-fill, color stability, discoloration, repolishing, resin composite*

## Introduction

The most popular materials for restorative dental applications are composite resins, which produce excellent outcomes in terms of both aesthetics and functionality. The physical and mechanical characteristics of these materials are continually improving as a result of technological advancements and academic research (1). In recent years, bulk-fill composite resins have been used in posterior teeth, allowing layering up to 4 or 5 mm thick in one step, accelerating the restoration process (2). In the restoration of teeth, composite resins with different sized particles created using nanotechnology are now frequently used (3). Thanks to the improvements made in the structures of composite resins, their clinical life is extended, and the color mismatch between the restored tooth and the material is reduced. The color change of resin materials has gained importance in the choice of restorative materials.

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Discoloration in composites can be due to internal and external factors. Internal factors include self-coloring of the resin material and oxidation or hydrolysis in the resin matrix (4). External factors such as discoloration resulting from exposure to coloring agents and their absorption by the material, as well as the degree of staining varying with oral use, can cause changes in resin-based materials. Beverages such as coffee, tea, cola, and red wine can cause varying degrees of staining on the resin materials (5). Coffee can act as a coloring agent that has the ability to penetrate the organic phase of composite resins and release low-polarity yellow pigments, leading to discoloration (6).

Finishing and polishing processes are important steps after restorations are completed. Optimal finishing and polishing increase both the aesthetics and longevity of the restoration. The presence of irregular areas in the restoration can cause plaque retention, surface discoloration, and the formation of secondary caries (7). Therefore, ensuring the smoothness of the surface of composite resins is a key factor affecting clinical success (1). The color change of materials is affected by external factors, the properties of the particles, polishing systems, and composition (3). The contents of polishing materials include diamond or carbide burs, polishing discs, diamond-embedded rubber spirals, silicon carbide brushes, and polishing pastes. These polishers, which are used in one or more steps in the finishing and polishing process, vary greatly in compositions, type, and hardness of the abrasive (8).

The surface texture of a tooth-colored restoration can have a significant impact on plaque formation, discoloration, wear, and the overall esthetic appearance of the restoration. Therefore, proper finishing and polishing are critical procedures that can increase both the aesthetics and lifespan of restored teeth (4). Recent studies have shown that resin composites, which are commonly used for tooth restoration, exhibit less discoloration after finishing and repolishing (3,4). Studies examining the color stability of the resin materials after repolishing procedures are limited. Although new, simplified polishing systems are less time consuming, there is not enough information about the color change of these finishing and polishing systems with different repolishing procedures. Therefore, the purpose of this study is to assess the impact of various repolishing procedures on the color change of bulk-fill resin composites after exposure to a coffee solution. The null hypothesis of this study is that the repolishing procedures would not affect the color change of bulk-fill resin composites after exposure to a coffee solution

## Material and Methods

*Ethical approval*

The ethical approval for the study was obtained from the Usak University, Faculty of Dentistry, Non-Invasive Clinical Research Ethics Committee (43-43-18).

*Sample size estimation*

The sample size was determined using G*Power 3.1. Considering the parameters examined in a previous study, a medium effect size, 95% confidence level (1-α), and 80% test power (1-β), 10 samples for each group were deemed sufficient (3).

*Study materials*

Table 1 shows the materials used for this study. CIEDE 2000 formula (Figure 1) and flow chart (Figure 2) are indicated..

**Table 1.** *Composition of the resin composites*

| | Manufacturer | Type | Composition content | Filler weight % | Lot |
|---|---|---|---|---|---|
| **Filtek One Bulk-Fill Restorative** | 3M-ESPE, St. MN Paul, USA | Bulk-Fill | UDMA, DDDMA, Zirconia/silica (4-20 nm) cluster filler, ytterbium fluoride (100 nm) AUDMA, AFM, and 1, 12-dodecane-DMA, camphorquinone | 76.5 % w | NC6052 |
| **Tetric EvoCeram Bulk-Fill** | Ivoclar Vivadent, Schaan, Liechtenstein | Bulk-Fill | Bis-GMA, Bis-EMA, UDMA,barium glass, ytterbium trifluoride, mixed oxide, silica nanohybrid;(17% pre-polymers), Lucirin, Ivocerin, camphorquinone | 78-81 % w | Z0032W |
| **Admira Fusion x-tra** | Voco GmbH, Cuxhaven, Germany | Ormocer bulk-fill | Ormocer, glass ceramics, silica nanoparticles, pigments | 84 % w | 1918494 |
| **Grandio SO x-tra** | Voco GmbH, Cuxhaven, Germany | Esthetic bulk-fill | Bis-GMA, Bis-EMA, aliphatic dimethacrylate, Inorganic filler, organically modified silica | 86 % w | 1910205 |
| **Polishing systems** | | | | | |
| **Optragloss** | Ivoclar Vivadent, Schaan, Liechtenstein | | Spiral wheel system for composite polishing (diamond-embedded) | | ZL09LD |
| **Nova Twist** | Nova Twist, Presidental, Munih, Germany | | Spiral wheel system for composite polishing (diamond-embedded) | | 479154 |

Bis-GMA: bisphenol A glycol dimethacrylate; Bis-EMA: bisphenol A ethoxylated dimethacrylate; TEGDMA: triethylene glycol dimethacrylate, UDMA: urethane dimethacrylate AUDMA: Aromatic urethane dimethacrylate; AFM: Addition-fragmentation monomer; DDDMA: 1, 12-Dodecanediol dimethacrylate

In the current study, four bulk-fill resin composites (Filtek One Bulk-Fill Restorative, 3M-ESPE, MN, USA; Tetric EvoCeram Bulk-Fill, Ivoclar Vivadent, Schaan, Liechtenstein; Admira Fusion x-tra, Voco GmbH, Cuxhaven, Germany; Grandio SO x-tra, Voco GmbH, Cuxhaven, Germany) shade tone equivalent A2 were tested.

*Sample preparation*

Resin composite specimens were prepared using disk-shaped Teflon molds with a diameter of 8 mm and a depth of 4 mm. The resin composites were placed in holes (bulk layer), and a mylar strip (Hawe Transparent Strip, Kerr Hawe, Bioggio, Switzerland) was placed over the top surface of samples. The Mylar strip was gently pressed with a glass plate at the top of each mold's surface, extruding the excess material. After removing the glass plate, it was polymerized at a power density of approximately 1200 mW/cm$^2$ for 20 seconds (Elipar S10; 3M ESPE; St. Paul, MN, USA). For surface standardization, a single surface of the samples in each group was finished using 1200-grit silicon carbide abrasive paper with water before application of the polishing systems.

A total of 240 disc-shaped samples were prepared (60 samples in each of the resin composite groups). The resin composite groups were randomly divided into two subgroups (n=30). One group was treated with a one-step polishing system (Optragloss, Ivoclar Vivadent, Schaan, Liechtenstein) using a diamond-embedded spiral wheel for 30 s in dry conditions. The other group was treated with a two-step polishing system (Nova Twist; President Dental, Munih, Germany). Nova Twist polishing system includes prepolishing and highshine polishing diamond-embedded spirals. Each spiral wheel was applied for 15 s in dry conditions. The polishing systems were applied using a handpiece at a speed of 10,000 rpm.

All specimens were rinsed for 10 s and then stored in distilled water in a Nuve Incubator (EN 055, Ankara, Turkey) at 37°C for 24 h. Initial color values of the resin composite samples were determined with a spectrophotometer (Lovibond RT Series, Tintometer Group, UK). Three measurements were made from each sample, the average of these measurements was taken, and the L, a, b values were recorded. The samples were immersed in a 300 ml solution of boiling water containing 3.6 g of coffee (Nescafe Classic; Nestle, Switzerland) and kept in the solution for 12 days (9). The samples kept in the solution at 37°C. The solution refreshed daily. To remove any excess staining agent, the samples were washed with distilled water for 1 minute and then dried following the staining procedure.

Repolishing procedures was applied to the resin composite samples: one-step repolishing (Group RO), two-step repolishing (Group RT), and non-repolishing group (Group RN) (n=10) (Figure 2). For the repolishing procedure, the same polishing protocol was applied to the materials previously described. Following the repolishing procedure, the color values of the samples were remeasured, and the color change values were determined using the CIEDE 2000 color formula (10,11) (Figure 1).

For each pair of samples, *ΔL′*, *ΔC′*, and *ΔH′* indicate the differences in lightness, chroma, and hue, respectively, using the CIEDE 2000 metric. To adjust for the location of color differences in *L′*, *a′*, and *b′* values, the weighting functions $S_L$, $S_C$, and $S_H$ were used. The parametric factors $K_L$, $K_C$, and $K_H$ acted as correction terms for the experimental conditions. Furthermore, $R_T$ was used as a rotation function that takes into consideration how chroma and hue variations interact in the blue region (10,11). In this study, parametric factor values of 1 were accepted based on a previous study (7). Color change threshold values were based on a previous study (11).

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

***Figure 1.*** *CIEDE 2000 color formula used in the present study for color changes.*

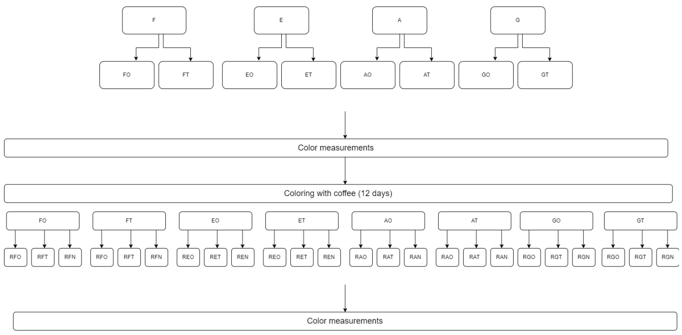


***Figure 2.*** *Flow chart of study plan.*
*F; Filtek One bulk-fill, E; Tetric EvoCeram bulk-fill, A; Admira Fusion x-tra bulk-fill, G; Grandio SO x-tra bulk-fill, O; one-step polishing, T; two-step polishing, N; non-polishing, R; repolishing*

*Statistical analysis*

Statistical analysis of the data was performed using SPSS Statistics, Version 25 (IBM Corp., Armonk, NY, USA). For bulk-fill composites, the $\Delta E_{00}$ data (normality checked with Kolmogorov–Smirnov and skewness-kurtosis tests) were analyzed using a three-way analysis of variance (main effects and interactions). Tukey's test was used for multiple comparisons (p<0.05).

## Results

Three-way ANOVA results, significant factors and interaction between the factors showed in Table 2. The means and standard deviations of the color change ($\Delta E_{00}$) values were indicated for the resin composite groups in Table 3. The $\Delta E_{00}$ values of the resin materials ranged between (0.96 ± 0.28) and (5.43 ± 1.57). Composite, the polishing sytem, repolishing group were considered main effects for color stability (p<0.001, p<0.001, p<0.001 respectively). Moreover, repolishing effect ($\eta^2$=0.675) was found a more effective factor than composite ($\eta^2$=0.315). In terms of composite materials, Filtek One bulk-fill (1.84 ± 0.98) presented significantly a lower of color change than the other composites (p<0.001). There was no significant differences between Tetric-EvoCeram bulk-fill, Admira x-tra bulk-fill, Grandio SO x-tra bulk-fill (p >0.05). In terms of polishing sytems, Optragloss (2.96 ± 1.51) presented a significantly greater color change than Nova Twist system (2.21 ± 1.07) (p<0.001) (Table 3). The combination of Optragloss with Admira x-tra bulk-fill indicated

**Table 2.** *Three-way ANOVA results for color change of main effects and interactions between factors*

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 341.016$^{a}$ | 23 | 14.827 | 31.607 | <0.001 | 0.771 |
| Intercept | 1607.943 | 1 | 1607.943 | 3427.723 | <0.001 | 0.941 |
| f1 | 46.660 | 3 | 15.553 | 33.156 | <0.001 | 0.315 |
| f2 | 33.794 | 1 | 33.794 | 72.040 | <0.001 | 0.250 |
| f3 | 210.220 | 2 | 105.110 | 224.067 | <0.001 | 0.675 |
| f1*f2 | 22.570 | 3 | 7.523 | 16.038 | <0.001 | 0.182 |
| f1*f3 | 10.677 | 6 | 1.780 | 3.794 | 0.001 | 0.095 |
| f2*f3 | 12.435 | 2 | 6.218 | 13.255 | <0.001 | 0.109 |
| f1*f2*f3 | 4.660 | 6 | 0.777 | 1.656 | 0.133 | 0.044 |

a R Squared = .771 (Adjusted R Squared = .747)
*(f1;composite, f2;polishing system, f3;repolishing procedure).*

**Table 3.** *Means and standard deviations for $\Delta E_{00}$*

| | | Composites | | | | |
|---|---|---|---|---|---|---|
| **polishing systems** | **Groups** | **Filtek One** | **Tetric EvoCeram** | **Admira x-tra** | **Grandio SO x-tra** | **Total** |
| one-step | Group RN | 3.46±0.77 | 4.58±0.57 | 5.43±1.57 | 4.43±0.54 | 4.47±1.16$^{a}$ |
| | Group RO | 1.52±0.48 | 2.32±0.41 | 3.64±1.29 | 3.37±0.46 | 2.71±1.12$^{bc}$ |
| | Group RT | 1.33±0.47 | 1.61±0.54 | 1.94±0.45 | 1.95±0.77 | 1.71±0.61$^{d}$ |
| | Total | 2.10±1.13$^{A}$ | 2.83±1.38$^{A}$ | 3.67±1.86$^{B}$ | 3.25±1.19$^{C}$ | 2.96±1.51$^{X}$ |
| two-step | Group RN | 2.41±0.56 | 3.79±0.93 | 2.57±0.34 | 3.54±0.76 | 3.08±0.89$^{c}$ |
| | Group RO | 1.36±0.26 | 2.84±0.70 | 2.14±0.62 | 2.83±0.69 | 2.29±0.84$^{b}$ |
| | Group RT | 0.96±0.28 | 1.39±0.54 | 0.96±0.13 | 1.76±0.58 | 1.27±0.53$^{d}$ |
| | Total | 1.58±0.73$^{A}$ | 2.68±1.23$^{A}$ | 1.89±0.80$^{D}$ | 2.71±0.99$^{A}$ | 2.21±1.07$^{Y}$ |
| Total | Group RN | 2.93±0.85$^{ae}$ | 4.18±0.85$^{c}$ | 4.00±1.84$^{ce}$ | 3.99±0.79$^{cf}$ | 3.78±1.25* |
| | Group RO | 1.44±0.38$^{bd}$ | 2.58±0.62$^{ag}$ | 2.89±1.25$^{fg}$ | 3.10±0.63$^{a}$ | 2.50±1.01** |
| | Group RT | 1.15±0.42$^{b}$ | 1.50±0.54$^{d}$ | 1.45±0.59$^{d}$ | 1.86±0.67$^{dg}$ | 1.49±0.61*** |
| | Total | 1.84±0.98$^{x}$ | 2.75±1.3$^{y}$ | 2.78±1.68$^{y}$ | 2.98±1.12$^{y}$ | 2.59±1.36 |

Goup RO; Repolishing one-step, Group RT; Repolishing two-step, Group RN; Non-repolishing. There is no difference between the same lower letter (x-y; between the composites) in the row. There is no difference between the same lower letter (a-g; interaction composite*repolishing) in the table. There is no difference between the same symbol ((*); between the repolishing) in the column. There is no difference between the same capital letter (A-D; interaction composite*polishing) in the table. There is no difference between the same lower letter (a-d; interaction polishing*repolishing) in the column. There is no difference between the same capital letter (X-Y; between the polishing systems) in the column.

the highest color change (3.67 ± 1.86), whereas the combination of Nova Twist with Filtek One bulk-fill indicated the lowest color change (1.58 ± 0.73) (Table 3). In terms of repolishing groups, non-repolishing groups (3.78 ± 1.25) presented a significantly greater color change than Nova Twist system (1.49 ± 0.61) and Optragloss system (2.50 ± 1.01) ($p<0.001$, $p<0.001$ respectively) (Table 3).

## Discussion

The surface properties of tooth-colored restorations can affect plaque, discoloration, and the esthetic appearance of the restorations (12). Thus, to maintain the optimal clinical performance and aesthetics of tooth-colored restorations, it is essential to prioritize proper finishing and polishing procedures during the restorative process (13). In this study, the effect of repolishing procedures on the color change of resin composite samples colored with coffee and then polished using different polishing systems was investigated. As a result of the study, it was found that repolishing procedures affected the color change. Therefore, the null hypothesis of the study was rejected.

Coffee which was selected as the coloring solution in our study, is a frequently preferred beverage in daily life. According to the manufacturers, a cup of coffee is consumed in an average of 15 minutes. Assuming that an individual who drinks coffee consumes 3.2 cups of coffee a day, keeping the samples in coffee for 48 hours would correspond to 2 months of coffee consumption (9). Considering these rates, composite resin materials were kept in coffee for 12 days, corresponding to 1 year of coffee consumption. Since composite resin materials can absorb water, liquids containing pigments cause discoloration in the resin composite (14). Coffee contains substances that form a yellow color at low polarity (15). In our study, color change values of polished resin composite samples immersed in coffee for 12 days were observed in the range of (1.84 ± 0.98) and (2.98 ± 1.12). This result is consistent with other studies indicating that coffee causes color change in resin composites (14,16,17). Water absorption is mostly due to absorption in the resin matrix. The water absorption rate is related to the resin contents of the materials and the bonding of the resin–filler interface. Water absorption causes the resin to expand and become plastic. This creates an environment for micro-cracks that cause stain penetration and color change in the resin composite or the formation of interfacial gaps between the filler and the matrix (18). The Filtek One bulk-fill showed less color change than the others. The color variation and coloring of resin materials are linked to the size, type, and amount of fillers particle (19,20). In the previous study, it was stated that the color change of the Filtek One bulk-fill was lower than the Tetric EvoCeram bulk-fill. The lowest color change of the Filtek One bulk-fill was attributed to the hydrophilic property of the resin material (21). The UDMA matrices can obtain higher hardness values than Bis-GMA based matrices. This could be explained as the UDMA has low viscosity which increase its degree of conversion and form denser polymer network (22,23). Consequently, plasticization effect on the polymer structure of resin composite, leads to the chemical instability and hydrolytic deterioration of resin-filler interface which accordingly reduce polishing retention and color stability over time (19).

Ormocer is a molecule formed by hydrolysis and polycondensation processes with a long chain inorganic silica backbone and lateral organic chain (24). The incorporation of Ormocer in composites results in a more cross-linked polymer network, leading to a higher degree of conversion, reduced polymerization shrinkage, improved surface hardness, increased toughness, and better color stability. Furthermore, when the number of chemical interactions between methacrylate groups increases, the amount of free unreacted monomers in the polymer network decreases (25). Color stability can be due to a mixture of matrix breakdown by acid, colorant penetration/absorption into the material, and colorant adhesion/adsorption to the surface (26). This may indicate that lower color stability and higher solubility are associated with monomer structures, for which colorant affects the chemical structures. In a previous study, microhybrid composites were found to be more stain resistant than nanocomposites and microfilled composites (27). According to Tagtekin *et al.,* Ormocer has a greater surface roughness than standard hybrid resin composites. The color deterioration in the Admira x-tra bulk-fill composite may be because the filler particles in the employed Ormocer are tougher than the matrix (28).

Composite resins exhibit color instability, which can be attributed to both intrinsic and extrinsic factors. External factors that affect the performance of dental composites include the duration and intensity of light curing, as well as exposure to environmental elements such as water, heat, and food coloring agents. Intrinsic factors that can affect color change in composite resin materials include the degree of conversion, the presence of impurities or contaminants, and the type of pigments or dyes used in the materials (29). The color change of materials results from the combination of axis movements. The literature offers several explanations for the color change of resins, including camphorquinone residues, vinyl group changes, polymerization of composite resins, and the breaking of chemical linkages (30). Color stability in restorations may result from a lack of polymerization, which contributes to the absorption of coloring chemicals. Factors may lead to color instability in restorations due to inadequate polymerization, resulting in the absorption of coloring agents (31). Smaller filler particle is less prone to discoloration due to water aging than larger filler particle. However, it is crucial to note that the number of filler particles is partly to blame for staining, since the resin composite can absorb more water (32). A portion of the light is lost due to variables impacting the optical characteristics, such as intrinsic absorbance, porosity, and roughness (19). Light transmittance falls exponentially as absorbance increases, altering reflectance and, as a result, color values (33). However, further inherent factors, such as the purity of the monomers, initiators, inhibitors, activator (type and concentration) and filler loading, have affect the color stability of resin materials (34).

Previous study stated the effect of polishing materials on the color change of resin materials and highlighted that polishing improves the color stability of restorative materials (13). After finishing/polishing, the surface micromorphology of composite materials is affected by the type, amount, size, and hardness of filler particle in composite materials. Previous studies have reported similar constraints, such as the operator variable and type of movement performed during polishing (35,36,37). The final appearance of a tooth-colored restoration can also be influenced by the flexibility of the finishing material, the abrasiveness of the polishing material, the size of the abrasive particles, and the technique used for application (38). Several studies have found that multi-step systems indicate better than one-step systems (7,8). One-step systems can be implemented with a single polishing material, and smooth surfaces are provided in a shorter time (7). The texture of the final surface depends on the technique and material used, but there is no consensus on the materials and techniques that provide the smoothest surfaces for resin composites (39,40).

In this study, the color changes of specimens were analyzed using a spectrophotometer with the CIEDE 2000, which was developed to overcome the limitations of the CIE Lab* (41,42). The evaluation of restorative materials' efficacy and the interpretation of both visual and instrumental data are crucial, perceptibility threshold (PT) and acceptability threshold (AT) are defined as measures of the extent of differences. A color change value that is perceptible by 50% of observers is referred to as 50:50% PT, and the color change value that is clinically acceptable to 50% of observers is referred to as 50:50% AT (43,44). In clinical dentistry, the determination of threshold values for visual perceptibility and acceptability plays a crucial role in the assessment of color differences in dental restorations (45). In our study, color changes of resin composites were considered 50:50% acceptability threshold (AT:$\Delta E_{00} = 1.8$) and 50:50% perceptibility threshold (PT:$\Delta E_{00} = 0.8$) (43). Based on the results of the in this study, the clinically unacceptable color change values for composite resin samples were found to be ($3.78 \pm 1.25$) in the non-repolishing group and ($2.50 \pm 1.01$) in the one-step group after the repolishing procedure. In addition, when polishing systems are evaluated, the Nova Twist system (two-step) had lower color change values than the Optragloss system (one-step). Ideal polishing protocols are described as a selective wear protocol using a series of abrasive particles ranging from coarse to fine grit (46). Multistep systems use smaller particles at each step to remove scratches created by the previous step (47). For polishing systems containing diamond particles, a greater number of steps can eliminate the irregularities that occurred during the application stage. This study found that the two-step system preserved the color stability of the repolishing groups. Moreover, the repolishing application contributed to the color stability for both systems. According to Heintze *et al.*, spiral wheels may provide a clinical advantage when used on curved dental surfaces (48). It has been reported that in addition to the size and shape of abrasives, the effectiveness of polishing can also be influenced by factors such as their binding to the matrix and the type and flexibility of the matrix (49). In addition, for color change; the partial eta squared for the repolishing variable was $\eta^2 = 0.675$, while the partial eta squared for the composite variable was $\eta^2 = 0.315$. These findings indicate that the repolishing has a higher effect on the color change than the resin material contents. Based on the findings of the study, it highlights the importance of repolishing for composite resins.

There are limitations associated with this study. This study was conducted *in vitro*, which may not be representative of clinical situations. Intraoral conditions may result in discoloration of restorative materials. Additionally, the extrinsic discoloration caused by beverages could be decreased or even negated with oral hygiene routines. It would be appropriate to consider the effect of brushing in discoloration studies. Future studies using *in vitro* and *in vivo* methods should conduct different parameters and materials.

## Conclusion

Repolishing of resin composites exposed to coloring decreases the color change of resin composites. Less color change was observed for the two-step repolishing system compared to the one-step repolishing application. The color change of the one-step repolished and non-polished resin composites were above the clinically unacceptable level after 12 days. Two-step polishing systems may be preferred in terms of maintaining color stability. In polishing systems containing diamond particles, increasing the number of steps can contribute to color stability. The content of the resin material is also an important factor in color stability.

**Türkçe özet:** *Farklı yeniden cilalama prosedürlerinin bulk-fill rezin kompozitlerin renk değişimi üzerine etkisinin incelenmesi. Amaç: Bu çalışmanın amacı, yeniden cilalama prosedürlerinin kahve solüsyonuna maruz kaldıktan sonra bulk-fill rezin kompozitlerde renk değişimi üzerindeki etkisini değerlendirmektir. Gereç ve yöntem: Dört bulk-fill rezin kompozit (Filtek One bulk-fill, Tetric Evoceram bulk-fill, Admira Fusion x-tra bulk-fill, Grandio SO x-tra bulk-fill) test edildi. Rezin kompozit gruplarının her birinde 60'ar örnek hazırlandı ve polisaj sistemine göre rastgele iki gruba ayrıldı: tek aşamalı polisaj sistemi (Optragloss) ve iki aşamalı polisaj sistemi (Nova Twist) (n=30). Örnekler 12 gün kahvede bekletildikten sonra yeniden polisaj uygulanmasına göre üç alt gruba ayrıldı; tek aşamalı yeniden cilalama grubu, iki aşamalı yeniden cilalama grubu, yeniden cilalama yapılmayan grup (n=10). Rezin kompozit örneklerin renk ölçümleri spektrofotometre ile belirlendi. Renk değişimi farkı, CIEDE 2000 renk formülü kullanılarak hesaplandı. Veriler, üç yönlü varyans analizi ve Tukey testi kullanılarak analiz edildi (p<0.05). Bulgular: Kompozit materyaller bakımından, Filtek One (1,84 ± 0,98) diğer kompozitlere göre anlamlı derecede daha düşük renk değişimi gösterdi (p<0.001). Polisaj sistemleri bakımından Optragloss (2,96 ± 1,51), Nova Twist'e (2,21 ± 1,07) göre daha fazla renk değişimi gösterdi (p<0.001). Yeniden cilalama grupları bakımından, yeniden cilalama yapılmayan gruplar (3,78 ± 1,25), Nova Twist sistemine (1,49 ± 0,61) ve Optragloss sistemine (2,50 ± 1,01) göre anlamlı ölçüde daha fazla renk değişimi gösterdi. Sonuç: Yeniden cilalama işlemi renk değişimini azaltmıştır. İki aşamalı polisaj sistemi uygulandığında, tek aşamalı polisaj sistemine göre en az renk değişikliğini oluşturmaktadır. Elmas partikülleri içeren polisaj sistemlerinde polisaj aşama sayısının artması renk stabilitesine katkı sağlayabilir. Anahtar kelimeler: bulk-fill, renk stabilitesi, renk değişikliği, yeniden cilalama, rezin kompozit*

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