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Research Araştırma

Evaluation of the Effect of Different Finishing and Polishing Systems on Surface Roughness and Color Stability of Different Restorative Materials

Farklı Bitirme ve Cila Tekniklerinin Çeşitli Restoratif Materyallerin Yüzey Pürüzlülüğü ve Renk Değişimine Etkisinin İncelenmesi

ABSTRACT

Objectives: The aim of this in vitro study is to evaluate the effect of different finishing and polishing systems on surface roughness and color stability of different restorative materials.
Material and Methods: Glass hybrid (Equia Forte), glass carbomer (GCP Glass Fill), resin modified glass ionomer (Fuji II LC), compomer (Dyract XP) and microhybride composite (Filtek Z250) materials are used and 150 disc-shaped specimens were prepared. Specimens randomly divided into Mylar strip, aluminum oxide discs and polishing rubber subgroups. Surface roughness is determined by a Profilometer, baseline and after 48 hours immersion in coffee color measurements are made with a spectrophotometer. Statistical analyses are made with two-way ANOVA, Tamhane's test and Pearson correlation tests.
Results: : The highest Ra values are obtained at Equia Forte (1.21) and GCP Glass Fill (1.14), the lowest at Filtek Z250 (0.24) and Dyract XP (0.27) groups. The lowest Ra values of finishing and polishing systems are obtained at control (0.56) and Sof-Lex (0.56) groups, the highest at OneGloss (1.06). The lowest ΔE value is obtained at GCP Glass Fill (1.41) and the highest at Fuji II LC (5.41) and Equia Forte (5.31) groups. The lowest ΔE value of finishing and polishing systems is obtained at Sof-Lex (3.51) and the highest at OneGloss (4.59) group.
Conclusion: Polishing rubbers showed more surface roughness and color change than aluminum oxide discs. But the efficiency of finishing and polishing system depends on the restorative materials too.
Key Words: Glass Carbomer, Glass Hybrid, Surface Roughness, Color Stability

ÖZ

Amaç: Bu in vitro çalışmanın amacı farklı bitirme ve cila tekniklerinin çeşitli restoratif materyallerin yüzey pürüzlülüğü ve renk değişimine etkisinin incelenmesidir.
Gereç ve Yöntemler: Cam hibrit (Equia Forte), cam karbomer (GCP Glass Fill), rezin modifiye cam iyonomer siman (Fuji II LC), kompomer (Dyract XP) ve mikrohibrit kompozit (Filtek Z250) restoratif materyalleri kullanılmış ve toplam 150 adet örnek hazırlanmıştır. Örnekler rastgele bitirme ve cila uygulanmayan (kontrol), çok aşamalı alüminyum oksit diskler uygulanan (SofLex), tek aşamalı cila lastiği uygulanan (OneGloss) altgruplarına ayrılmıştır. Örneklerin yüzey pürüzlülük (Ra) değerleri Profilometre cihazı ile, başlangıç ve 48 saat kahvede bekletildikten sonraki renk değerleri ise spektrofotometre ile ölçülmüştür. İstatistiksel analiz çift yönlü Anova ve Tamhane çoklu karşılaştırma testleri ve Pearson korelasyon analizi ile yapılmıştır.
Bulgular: En yüksek Ra değerleri Equia Forte (1,21) ve GCP Glass Fill (1,14) en düşük Ra değerleri ise Filtek Z250 (0,24) ve Dyract XP (0,27) gruplarında görülmüştür. Bitirme ve cila tekniklerinde ise en düşük Ra değerleri kontrol (0,56) ve Sof-lex (0,56) grubunda görülürken en yüksek Ra değeri OneGloss (1,06) grubunda görülmüştür. En düşük ΔE değeri cam karbomer (1,41), en yüksek ΔE değeri ise Fuji II LC (5,41) ve Equia Forte (5,31) gruplarında görülmüştür. Bitirme ve cila gruplarında ise en düşük ΔE değeri Sof-Lex (3,51) en yüksek ΔE değeri OneGloss (4,59) grubunda görülmüştür
Sonuç: Cila lastiklerinin bitirme ve cila disklerine göre daha fazla pürüzlülük ve renk değişimi gösterdiği görülmüştür. Ancak bitirme ve cila sistemlerinin etkinliğinin restoratif materyallere de bağlı olduğu anlaşılmıştır..
Anahtar Kelimeler: Cam Hibrit, Cam Karbomer, Yüzey Pürüzlülüğü, Renk Değişimi

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INTRODUCTION

Because of the increasing esthetical needs in dentistry, many tooth-colored restorative materials were developed. Composite resins and glass ionomers have an important place among them (1). Under favor of their advantages such as adhesion, fluoride release, biocompatibility and low polymerization contraction, the glass ionomers were restorative materials that are alternative to the composite resins. But because of their disadvantages such as weak mechanical properties and moist sensitivity, to combine the advantages of glass ionomers and composite resins; resin modified glass ionomers and compomers were developed (2,3). Recently, the glass hybrids originating from high-viscosity glass ionomers and the glass carbomers which are glass ionomer based restorative materials containing hydroxyapatite degraded into nano sizes, were developed (4,5). Among the composite resins, which are the most frequently used tooth-colored esthetical restorative materials, the micro-hybrid composite resins have been widely used because of their advantages such as improved mechanical and physical properties and potential to be well-polished (6).

For the restorative materials, it is very important to achieve smooth surfaces, to have color match with natural tooth, and to ensure the durability of this matching. The surface roughness and the coloration are two most important parameters for evaluating the restorations (7,8).

The finishing and polishing procedures are the procedures that should be applied to restorative materials in order to adjust the restoration margins, to give the appropriate contours to restoration and to obtain shining and smooth surfaces (9). The finishing and polishing procedures were reported to affect the surface roughness and discoloration of the restorations (10,11). The appropriately performed finishing and polishing is an important step in terms of esthetic and durability of restoration (12).

In the light of these information, the aim of this study was to evaluate the effects of various polishing and finishing methods on the surface roughness and color stability of various current restorative materials that have wide areas of use and the hypothesis of this study was that different finishing and polishing systems would effect the surface roughness and color stability of various restorative materials.

MATERIAL AND METHODS

In the present in vitro study five different restorative materials and two different finishing and polishing systems were used. The restorative materials selected to be used were glass carbomer (GCP Glass Fill, GCP Dental, Riedderkerk, Netherlands), glass-hybrid (Equia Forte, GC Dental, Tokyo, Japan), resin-modified glass ionomer cement (Fuji II LC, GC Dental, Tokyo, Japan), compomer (Dyract XP, Dentsply, DeTrey, Konstanz, Germany) and micro-hybrid composite resin (Filtek Z250, 3M/ ESPE, Mn, USA) restorative materials; all of these materials were selected to have A2 color. The finishing and polishing systems that were selected in order to apply finishing and polishing to the specimens prepared by using these restorative materials were one-step finishing and polishing system One-Gloss (Shofu Inc., Kyoto, Japan) and multi-step finishing and polishing system Sof-Lex (3M/ ESPE, Mn, USA). The restorative materials used are presented in **Table 1** and the finishing and polishing systems are shown in **Table 2**.

Specimen Preparation

The Teflon molds having 10mm diameter and 2 mm thickness were used for preparing the specimens from restorative materials. Totally 150 specimen discs, 30 from each restorative material, were prepared. During the preparation of specimens, the restorative materials were placed into the Teflon molds, which were placed on a glass slide having Mylar strip on it, in the way there is no air bubble inside. Then, by placing Mylar strip and glass slide again on the top of mold and pressing on it, the excess amount of material was removed. The restorative materials were prepared according to the instructions of manufacturers. The restorative materials procured in capsule form were mixed in a mixer and then applied to the molds by using a capsule applier.

GCP Glass Fill (GCP Dental, Riedderkerk, Netherlands) restorative material was applied to the mold after mixing each capsule in mixer for 15seconds and applied to the molds. After then in accordance with the recommendation of manufacturer, the GCP Gloss (GCP Dental, Riedderkerk, Netherlands) surface coating was applied and GCP CarboLED (GCP Dental, Riedderkerk, Netherlands) light device was used for applying heat and light for 90 seconds.

Restorative Materials	Type	Manufacturer	Lot Number	Composition
GCP Glass Fill (GC)	Glass Carbomer	GCP Dental, Riedderkerk, Netherlands	7605679	Fluoroaluminosilicate glass >90%, Apatite<6%, Polyacide < 4%
Equia Forte (EF)	Glass Hybrid	GC Dental, Tokyo, Japan	1608171	Fluoroaluminosilicate glass
Fuji II LC (FL)	Resin Modified Glass Ionomer	GC Dental , Tokyo, Japan	1601271	Polyacrylicacide, HEMA, UDMA, TEGDMA, Fluoroaluminosilicate glass
Dyract XP (DX)	Compomer	Dentsply,DeTrey, Konstanz, Germany	1611000 45	Sr,Al,N, Fluorosilicateglass, Stronsium floride, BisGMA,UDMA, TEGDMA, TCB, TMPTMA, Camphoroquinone
Filtek Z250 (FZ)	Microhybride Composite Resin	3M /ESPE, Mn, USA	N793935	Bis-GMA, UDMA, Bis- EMA, Zirconia and Silica Fillers (0,01-3,5µm)
GCP Gloss	Surface Coating for Glass Carbomer	GCP Dental, Riedderkerk, Netherlands	1511140	Modified Polysiloxane
Equia Forte Coat	Nano filled Surface Coating for Glass Hybrid	Gc Dental,Tokyo, Japan	1608051	Metylmetacrylate, Colloidal silica, Camphoroquinone, Uretan metacrylate, phosphoric esther monomer

Table 1: The information about restorative materials used in this study

Finishing/ Polishing Systems	Type	Manufacturer	Lot Number	Shape	Step Type
Sof-Lex (S)	Aluminum oxide coated discs (coarse,medium,fine ,super fine)	3M/ESPE,Mn, USA	N764379	Disc shaped	Multi-step
OneGloss (O)	Abrasive (Al_2O_3) and silicone oxide (SiO_2) in Polyvinylsiloxane	Shofu Inc., Kyoto, Japan	1112318	Disc shaped	One-step

Table 2: The information about finishing and polishing systems used in this study

Equia Forte (GC Dental, Tokyo, Japan) restorative material was applied to the mold after mixing each capsule in mixer for 10 seconds and then allowed to set at room temperature for 5 minutes. After setting, in accordance with the manufacturer recommendations, Equia Forte Coat (GC Dental, Tokyo, Japan) surface coating was applied and then polymerized for 20 seconds by using Elipar S10 (3M/ESPE, Mn, USA) Light Emitting Diode (LED) light device. Fuji II LC (GC Dental,Tokyo, Japan) restorative material was applied to the mold after mixing each capsule in mixer for 10 seconds and then polymerized for 20 seconds by using Elipar S10 (3M/ESPE, Mn, USA) LED light device. Dyract XP (Dentsply, DeTrey, Konstanz, Germany) and Filtek Z250 (3M/ESPE, Mn, USA) restorative materials are polymerized for 20 seconds by using Elipar S10 LED light device after applying to the molds.

During these procedures a radiometer is used to check the light device's light intensity (Hilux, Benlioğlu Dental A.Ş., Ankara, Turkey).

And then, specimens were taken out of the molds and 150 specimens were randomly divided into 15 subgroups (n=10) by making randomly selection from each restorative material group in order to use with Mylar strip, Sof-Lex and One Gloss finishing and polishing system groups.

Finishing and Polishing

Specimens in the groups except the control subgroups were sanded for 10 seconds by using 1000 grit silicon carbide sandpaper in order to achieve standard surfaces. Specimens in the control subgroups were not exposed to any finishing or polishing procedure and they were finished under Mylar strip. And then, all the specimens were rinsed with distilled water for 1 minute and then kept in distilled water at 37°C and 100% humidity for 24 hours.

For the specimens in Sof-Lex subgroups, the course, medium, fine, and superfine-grain discs were used, respectively. A new disc was used for each specimen. While using the coarse and medium discs, the micro-motor was run at 10,000 rpm for 10 seconds, whereas it was used at 30,000 rpm for 20 seconds for fine and superfine discs. These procedures were made in a dry environment (13). After the polishing procedures, the specimens were rinsed and dried.

For the specimens in OneGloss subgroups, the specimens were treated using micro-motor at 10,000 rpm for 30 seconds in a dry environment. A new polishing disc was used for each specimen. Then, the specimens were rinsed and dried.

Surface Roughness Measurement

The surface roughness measurements of specimens were carried out using profilometer device (Perthometer M2, Mahr, Germany). Before the measurements, the profilometer device was calibrated. The specimens were placed on the plate perpendicularly to the edge. The surface roughness measurement was performed with the tip having 0.25mm "cut-off" value and 5.5mm tracking pathway by triplicating the measurement at different points. By calculating the average of these 3 measurements for each specimen, the mean roughness value represented by "Ra" was obtained.

Color Change Measurement

After the surface roughness measurement, the color measurements of specimens were performed. In determining the color, a spectrophotometer (SpectroShade, MHT Optic Research, Niederhasli, Switzerland) device was used. After the baseline color measurement each specimen was labeled with a number. And then, a coffee solution was prepared for coloring the specimens. The coffee solution was prepared by adding 3.6 grams coffee (Nescafe Classic, Nestle, India) into 300 ml boiled distilled water and stirring. The solution that was prepared was kept for 10 minutes and then filtered through the filter paper. And then, the specimens, which were numbered before, were placed into the molds in accordance with the number given them, respectively, and the coffee solutions were added onto them. And then, these molds were kept at 37°C for 48 hours. At the end of 48-hour storage in coffee solution, the specimens were rinsed with distilled water, and then dried by using paper towel. Then, for the second color measurement process was performed by using SpectroShade again. During the measurements, the device was calibrated at every 10 measurements.

The color measurements of each specimen (before and after the application of coffee solution) were triplicated and the L*, a*, and b* values were recorded for each measurement. The mean values of baseline color measurements were recorded as L0*, a0*, and b0*, whereas the mean values of second color measurements were recorded as L1*, a1*, and b1*. In order to calculate ΔE between two measurements, the formula presented below was used:

$$\Delta E^* = [(L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2]\ ½$$

Statistical Analysis

The data were analyzed using statistical software of IBM SPSS V23. The normality of distribution was analyzed using Shapiro Wilk test. The mean color change and surface roughness values were compared using two-way variance analysis. Among the multiple comparison tests, Tamhane test was used. The relationship between color and surface roughness was analyzed by using Pearson's correlation test. The results were expressed as arithmetical mean ± standard deviation. The level of significance was set to be $p<0.05$.

RESULTS

Surface Roughness

Mean Ra values and standard deviations obtained by applying three different finishing and polishing systems to the five restorative materials are shown in **Table 3**.

Given the mean values regarding the main effects of finishing and polishing techniques on the surface roughness, the mean values are ranked from lowest to highest was as follows: Control < Sof-Lex < OneGloss. There was no statistically significant difference between control and Sof-Lex groups ($p>0.05$), whereas the mean value of OneGloss group was found to be statistically significantly higher ($p<0.001$). The lowest mean surface roughness value was obtained in control subgroup of Dyract XP restorative material whereas the highest mean roughness value was obtained from the subgroup, in which OneGloss was applied to Equia Forte restorative material.

The lowest Ra values are obtained at control subgroups of all restorative materials except for GCP Glass Fill and Equia Forte. For GCP Glass Fill the highest Ra value is obtained at Control subgroup. For Equia Forte the lowest Ra value is obtained at Sof-Lex subgroup but there was no significant difference with control subgroup ($p>0.05$).

Restorative Material / Finishing/Polishing Systems	Control	Sof-Lex	OneGloss	General Mean Values
GCP Glass Fill	1.58 ± 0.27^{fg}	0.48 ± 0.26^{abcd}	1.36 ± 0.65^{efg}	1.14 ± 0.64^{C}
Dyract XP	0.05 ± 0.03^{a}	0.32 ± 0.28^{ab}	0.44 ± 0.27^{abcd}	0.27 ± 0.28^{A}
Filtek Z250	0.13 ± 0.28^{a}	0.22 ± 0.09^{a}	0.38 ± 0.08^{abc}	0.24 ± 0.20^{A}
Fuji II LC	0.12 ± 0.02^{a}	0.97 ± 0.51^{de}	1.22 ± 0.50^{ef}	0.77 ± 0.62^{B}
Equia Forte	0.90 ± 0.39^{cde}	0.83 ± 0.27^{bcde}	1.90 ± 0.68^{g}	1.21 ± 0.68^{C}
General Mean Values	0.56 ± 0.65^{A}	0.56 ± 0.42^{A}	1.06 ± 0.75^{B}	
*Different superscript letters in each row shows significant difference according to Tamhane multiple comparison test ($p<0.05$)				

Table 3: Mean surface roughness values (Ra) and standard deviations of analyzed restorative materials

The Ra values obtained from the surface roughness measurements were analyzed by using two-way variance analysis and then it was determined that the finishing and polishing procedures and interaction between materials and these procedures were significant. ($p<0.001$).

Given the mean values regarding the main effects of restorative materials on the surface roughness, the mean values are ranked from lowest to highest was as follows: FZ < DX < FL < GC < EF. There was no significant difference between mean Ra values of GC and EF groups and between DX and FZ groups ($p>0.05$). In FL group, the mean surface roughness value was obtained significantly different from the other groups ($p<0.001$).

Between the restorative material subgroups of Sof-Lex and OneGloss there was no statistically significant difference except GCP Glass Fill and Equia Forte restorative materials. ($p>0.05$) But between these two subgroups OneGloss produced significantly higher Ra values for these restorative materials. ($p<0.001$)

Color Stability

Mean ΔE values and standard deviations obtained by applying three different finishing and polishing systems to the five restorative materials are shown in **Table 4**.

The ΔE values obtained from the color measurements were analyzed by using two-way variance analysis and then it was determined that the finishing and polishing procedures and interaction between materials and these procedures were significant. ($p<0.001$).

Given the mean values regarding the main effects of restorative materials on the color stability, the mean values are ranked from lowest to highest was as follows: GCP <FZ< DX<EF <FL. There was no significant difference between mean ΔE values of FL and EF groups and between DX and FZ groups ($p>0.05$). In GCP Glass Fill group, the mean ΔE value was obtained significantly lower from the other groups ($p<0.001$).

As a result of the Pearson's correlation test that was performed, no statistically significant relationship was found between the surface roughness and the color stability. ($r=0.118$; $p=0.149$).

DISCUSSION

The surface roughness and discoloration are among the most important factors affecting the success of a restoration (7,8). The surface roughness might cause plaque retention and recurrent caries. Moreover, the color match and long-lasting color stability are also two important factors playing role in a successful esthetic restoration (14).

Restorative Material/ Finishing/ Polishing System	Control	Sof-Lex	OneGloss	General Mean Values
GCP Glass Fill	1.21 ± 0.84^{ab}	0.88 ± 0.23^{a}	2.15 ± 1.12^{b}	1.41 ± 0.96^{A}
Dyract XP	4.53 ± 0.49^{cde}	4.00 ± 0.65^{c}	3.53 ± 0.47^{c}	4.02 ± 0.67^{B}
Filtek Z250	3.61 ± 0.27^{c}	4.08 ± 0.49^{cd}	3.65 ± 0.46^{c}	3.78 ± 0.46^{B}
Fuji II LC	5.73 ± 0.22^{f}	5.08 ± 0.31^{def}	5.44 ± 0.89^{ef}	5.41 ± 0.61^{C}
Equia Forte	4.23 ± 0.65^{cd}	3.54 ± 0.6^{c}	8.16 ± 1.22^{g}	5.31 ± 2.24^{C}
General Mean Values	3.86 ± 1.6^{B}	3.51 ± 1.5^{A}	4.59 ± 2.26^{C}	

*Different superscript letters in each row shows significant difference according to Tamhane multiple comparison test ($p<0.05$)

Table 4: Mean color change values (ΔE) and standard deviations of analyzed restorative materials

Given the mean values regarding the main effects of finishing and polishing methods on the color stability, the mean values are ranked from lowest to highest was as follows: Sof-Lex < Control< OneGloss. The mean values of all the groups were found to be statistically significantly different from each other ($p<0.001$).

The lowest mean ΔE value was obtained in the group, in which Sof-Lex subgroup of GCP Glass Fill restorative material whereas the highest mean ΔE value was obtained from the subgroup, in which OneGloss was applied to Equia Forte restorative material.

The lowest ΔE values are obtained at Sof-Lex subgroups of all restorative materials except for Dyract XP and Filtek Z250. The lowest ΔE values are obtained at OneGloss subgroup for Dyract XP and at control subgroup for Filtek Z250 restorative materials.

Between the restorative material subgroups of Sof-Lex and OneGloss there was no statistically significant difference except GCP Glass Fill and Equia Forte restorative materials. ($p>0.05$) But between these two subgroups OneGloss produced significantly higher ΔE values for these restorative materials. ($p<0.001$)

It was shown that the smoothest surfaces for restorative materials form under the Mylar strips. But the surface forming under Mylar strip is a resin-rich layer that has weak mechanical properties and should be removed. For this reason, the finishing and polishing procedures should be applied in clinic (15,16). In previous studies, it was shown that various finishing and polishing procedures affect the surface roughness and color stability of restorations (7,11,14).

In parallel with the results of previous studies (3,17) it was determined in the present study that, considering the mean values obtained in Sof-Lex and OneGloss subgroups and also the general mean values, the Dyract XP was found to have higher Ra values than Filtek Z250 but there was no statistically significant difference. The reason for compomers' results that are similar to those of composite resins is thought to be that the compomers have a similar chemical structure with composite resins (18).

At the end of present study, Fuji II LC was found to have higher Ra values than Dyract XP and Filtek Z250, and these results are in parallel with previous

studies (1,11,13). The authors in a previous study reported that this is because the size of glass particles within the resin-modified glass ionomers is larger than the glass fillers in compomer and composite resins (13).
Mallya et al. (10) reported that the traditional glass ionomer cement containing no resin has higher surface porosity value than the resin-containing materials, and that the resin content within the structure of materials creates a smoother surface. Also in the present study, similar to the results of aforementioned study (10), the values of Equia Forte and GCP Glass Fill restorative materials having no resin content were found to be significantly higher in terms of surface roughness than those of other groups containing resin.

The Equia Forte restorative material is a glass hybrid but actually it originates from the high-viscosity glass ionomers. The glass ionomer cements are biphasic and heterogeneous materials. The hardened material consists of glass particles that haven't react within the poly-salt matrix. The finishing and polishing procedures of glass ionomers are more difficult because of their heterogeneity. Their soft matrix is easily abraded during the finishing and polishing procedures and there remain the hard glass particles (19,20). This is thought to play effective role in Equia Forte restorative material's higher roughness in comparison to those of other materials.

In many studies carried out before, it was reported that the smoothest surfaces were achieved in control groups finished under Mylar strip (9,15,21). In the parallel with these results, it was also determined in the present study that the minimum Ra values were obtained in control subgroups finished under Mylar strip in Dyract XP, Fuji II LC, and Filtek Z250 groups.

But for the GCP Glass Fill restorative material, the highest Ra value was obtained in control subgroup finished under Mylar strip, and both of OneGloss and Sof-Lex finishing and polishing materials offered lower Ra values than the control subgroup did. Comparing control and OneGloss subgroups, the difference was not statistically significant, whereas the Sof-Lex application was observed to significantly decrease the surface roughness in glass carbomer specimens, and for GCP Glass Fill the lowest Ra value was recorded in this finishing and polishing system. Similar to the results of present study, Bayrak et al. (22) carried out a study, in which they examined the surface roughness of various restorative materials against various finishing and polishing systems. Then, they reported that, among the glass carbomer (GCP Glass Fill), the surface roughness values of specimens finished under Mylar strip in control subgroup were higher than the specimens applied with multi-step (Sof-Lex) polishing and the specimens applied with two-step polishing (Enhance/PoGo, Dentsply/Caulk, Milford, DE, USA) procedures. They stated that this result may be because of the content of surface coating, which the manufacturer recommended to apply on the surface before polymerizing the material by using heat and light.

In aforementioned study of Bayrak et al. (22), the Ra values in control subgroup were found to be statistically higher than both of multi-step and two-step finishing and polishing subgroups. In the present study, however, no statistically significant difference was found between control and OneGloss one-step system subgroups. In this case, it can be stated that, for GCP Glass Fill, the two-step and multi-step finishing and polishing systems offered a remarkable improvement in surface roughness but the one-step systems couldn't reduce the surface roughness at the desired level.

For Equia Forte restorative material, the minimum Ra value was found in Sof-Lex subgroup, and the control subgroup was determined to have not statistically significantly but slightly higher. At the end of their study on examining the Ra values of a high-viscosity glass ionomer (Fuji IX) and a compomer (Vitremer) in terms of the use of surface coating, Pacifici et al. (19) reported that the nano-filler resin-containing surface coating (G Coat Plus, GC Dental,Tokyo,Japan) has no effect on the surface roughness. But no study carried out on Equia Forte restorative material was found. For this reason, it was thought that further studies would be useful to understand whether the reason for the higher level of surface roughness seen in the control subgroup of Equia Forte restorative material was the surface coating used.

Some of the factors which the efficiency of finishing and polishing procedures depends on are the hardness of abrasives, the material in which they are embedded, the geometry of instruments being used, and the types of use (23).

There are many studies reporting that better surface characteristics were achieved by using the aluminum discs in polishing the composite resins and glass ionomers (24-27) and also there are many studies reporting that the one-step OneGloss polishing discs yielding higher level of surface roughness in various restorative materials (3,28,29).

Considering the results of present study, it can be seen that, except for the GCP Glass Fill, the roughest surfaces were observed in OneGloss subgroups and these values were higher than the values of all Sof-Lex subgroups also for GCP Glass Fill. But, this difference between the results was found statistically significant only for GCP Glass Fill and Equia Forte.

Yap et al. (28) reported that the abrasives are embedded into polyvinyl siloxane in OneGloss polishing discs, that the polyvinyl siloxane delivery medium is more resistant to the wear by relatively softer poly-salt matrix and fluorosilicate glasses within the glass ionomer cements due to its high elasticity, and that it leads reducing efficiency of abrasives for these polishing discs. So, it is thought that, because of this situation, when compared to Sof-Lex discs, the OneGloss polishing discs are causing significantly more surface roughness for Equia Forte and GCP Glass Fill.

Even though it is accepted that the multi-step systems offer better results in finishing and polishing procedures, there are also studies reporting that the one-step and two-step systems which are offering saving time by reducing the number of steps in finishing and polishing procedure, show similar results to multi-step systems in terms of surface roughness (3,30,31).

In the light of these information, it can be stated that the efficiency of finishing and polishing systems is dependent upon the material, and that the polishing systems which have fewer steps and offer saving time have comparable efficiency to those of multi-step systems.

The tooth-colored restorative materials might suffer from discoloration due to internal and external factors. The internal coloration occurs because of the structure of the material itself, whereas the external coloration refers to the color change due to contact with coloring agent (7). In many studies carried out before, it was reported that one of the drinks causing discoloration at most is the coffee and it is frequently consumed in daily life (32,33).

The color change is represented with ΔE value in dentistry. There is no exact consensus on the clinically acceptable ΔE value. But, on the other hand, the critical value was accepted to be 3.7 in many studies (21,34,35). For this reason, the critical value was considered to be 3.7 in the present study, and the cases in which the restorative materials' ΔE values were higher than 3.7 were considered clinically unacceptable. In the present study, only the GCP Glass Fill restorative material showed clinically acceptable ΔE value in all the finishing and polishing subgroups, and its values were significantly lower than those of the other subgroups.

In the present study, when compared to Sof-Lex polishing system, the OneGloss polishing system created higher level of surface roughness on the restorative materials. But even though they showed color change statistically significantly more than Sof-Lex did when the general mean values are considered, this applied only to Equia Forte and GCP Glass Fill when considering the finishing and polishing subgroups of restorative materials. In Fuji II LC, Dyract XP, and Filtek Z250, there was no statistically significant difference between them and Sof-Lex discs. Moreover, they showed less color change than Sof-Lex did in Dyract XP and Filtek Z250 groups. For this reason, it can be stated that the effects of finishing and polishing methods on the color change are influenced not only by the roughness level that they create but also the structure of materials, on which they were applied.

Bagheri et al. (36) and Reis et al. (7) reported that the smoothest surfaces are not always the surfaces that are most resistant to the color change, and that the color change is mainly related with the structure of material. In the present study, even though the GCP Glass Fill showed the highest level of surface roughness together with Equia Forte, the minimum levels of color change were observed in this material in all the finishing and polishing subgroups and in terms of general mean values. At this point, it can be stated that the color change is not dependent only upon the surface roughness but also other factors and the structure of material's own plays an important role.

It was shown in previous studies that the coloration of resin-based restorative materials is related with the structure and water sorption of resin matrix, and that the water establishes the relationship between resin matrix and coloring pigments (36,37).GCP Glass Fill materials were shown to be resistant to water. It is thought that its low level of water sorption and water-solubility played important role in low level of discoloration in GCP Glass Fill restorative material (38).In the present study, the second lowest color change was observed in Filtek Z250 group and it is thought that this is because this material contains no TEGDMA molecule, which increases the water sorption, in its structure (32).

Hse et al (39) reported that the color stabilities of glass ionomers are insufficient depending on the polyacid content of cements and the degradation of metal poly-acrylate salts. Given the results of present study, it can be seen that Equia Forte restorative material showed color change more than any of the other groups, except for the Fuji II LC restorative material. Considering the Equia Forte restorative material's finishing and polishing subgroups, remarkably higher level of color change was observed in OneGloss creating significantly more rougher surfaces when compared to Sof-Lex and control subgroups. Although it was not statistically significant, the color change in the control subgroup of Equia, which showed rougher surface than the Sof-Lex subgroup, was again found to be higher than the color change in the Sof-Lex subgroup. At this point, it can be stated that there is a parallelism between the surface roughness values obtained in finishing and polishing subgroups of Equia Forte restorative material and the color change values.

The highest level of color change in the present study was observed in Fuji II LC material. But, however, there was no statistically significant difference with Equia Forte group. Some of the reasons for higher level of color change showed by Fuji II LC when compared to Dyract XP and Filtek Z250 are its more porous surface, more hydrophilic structure when compared to resin composites and compomers, and higher level of water sorption (40).

According to the results, the hypothesis of the present study which says finishing and polishing systems affects the surface roughness and color stability of restorative materials is accepted. But the findings showed no significant correlation between surface roughness and color stability so it has seen that color stability is related not only with surface roughness but also some other factors. Additionally the present study have some limitations. In the present study surface roughness measurements were made with mechanical profilometers. In further studies more detailed surface evaluation can be done by using SEM or AFM measuring devices. In our study two systems and coffee were used as finishing and polishing systems and coloring solution. A greater number and variety of finishing and polishing systems and different coloring drinks and liquids can be used in further studies. Additionally the present study is an in vitro study so there are limitations about imitating oral enviroment. So, it can be supported with further clinical studies.

CONCLUSION

Within the limitations of this study the following conclusions can be made;

1. Glass carbomer specimens showed significantly higher surface roughness values in Mylar strip subgroups compared to multi-step and one-step finishing/polishing systems. So it shows that GCP Glass Fill restorative materials must be polished after polymerizing.

2. The lowest and clinically acceptable color change values were obtained at glass carbomer specimens for all finishing/polishing subgroups.

3. No significant correlation between surface roughness and coloration was founded.

4. This study showed that the effects of finishing/polishing systems on surface roughness and color stability also depend on the restorative materials to which they are applied so appropriate finishing/polishing system must be used.,

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DISCLOSURE

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

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