The effect of polishing techniques on the surface roughness and color change of composite resins

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Statement of problem. Surface characteristics may affect the color change and surface roughness of composite resins.

Purpose. This study evaluated the surface roughness and color change of a hybrid, a microhybrid, and a nanohybrid composite resin polished with the use of polishing discs, wheels, and a glaze material.

Material and methods. Fifty discs (10 × 2 mm) were fabricated for each composite resin (nanohybrid, Grandio; microhybrid, Filtek Z250; hybrid, Quadrant Universal LC) for a total of 150 discs, prepared using polyester strips and divided into 5 groups of 10. One of the groups served as control (C) and had no surface treatment (n=10). The specimens of the experimental groups were ground with 1000-grit silicon carbide paper. In 4 experimental groups (n=10), specimen surfaces were polished with polishing discs (D) (Sof-Lex), with polishing wheels (W) (Astropol), with polishing discs preceding the glaze application (DG) (Biscover), or with polishing wheels preceding the glaze application (WG), respectively. Color was assessed using a small area colorimeter. The color differences (ΔE) values between the specimens of Group C and the experimental groups were calculated, and the data were compared using 2-way analysis of variance (ANOVA) (α=.05). Subsequently, the surface roughness (Ra) of the specimens was evaluated using a profilometer, and the data were analyzed by 2-way ANOVA followed by a Tukey multiple comparisons test (α=.05).

Results. The polishing technique and type of composite resin significantly affected the Ra and ΔE values of the composite resins ($P<.001$). While the use of polishing wheels produced the highest Ra values when compared to the other polishing techniques ($P<.001$), the nanohybrid composite resin showed the lowest Ra values compared to the other composite resins in the control groups ($P<.001$). All of the nanohybrid and microhybrid composite resin groups were found to be significantly different from each other in terms of color difference ($P<.001$).

Conclusion. The highest Ra values were obtained with hybrid composite resins due to the size of the filler particles that were exposed after polishing. Although the smoothest surfaces were obtained with polyester strips, the use of glaze material after polishing discs or polishing wheels resulted in significantly lower Ra and ΔE values than the use of the latter alone. The glaze appears to fill the structural microdefects and provide a more uniform, regular surface. (J Prosthet Dent 2006;96:33-40.)

CLINICAL IMPLICATIONS

In this in vitro study, the use of a polishing disc preceding glaze application was found to be superior to other polishing techniques tested, but not superior to the control group, in which the material was polymerized against a polyester matrix and received no surface treatment. After polishing the composite resin surface, the use of glaze material decreased the surface roughness and color change of the composite resin materials tested.

The clinical use of composite resins has increased substantially over the past few years due to increased esthetic demands by patients, improvements in formulation, and simplification of bonding procedures.[1] Composite resins are recommended for restoring all cavity classes in anterior and posterior teeth.[1] Regardless of the cavity class and location, a smooth surface finish is clinically important, as it determines the esthetics and longevity of composite resin restorations.[1]

Finishing and polishing of composite resin restorations are essential steps in restorative dentistry.[2] The esthetics and life span of tooth-colored restorative materials are dependent on the quality of the surface finish.[3] The presence of surface irregularities arising from poor finishing/polishing techniques and/or instruments may create clinical problems such as staining, plaque

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retention, gingival irritation, and recurrent caries.[1,3-8] Proper finishing of restorations is desirable not only for esthetics but also for oral health considerations by preventing plaque retention.[9] Finishing refers to the gross contouring or reduction of the restoration to obtain the desired anatomy.[9,10] Polishing refers to the reduction of the roughness and scratches created by the finishing instruments.[7,9-11] Composite resin surface roughness is usually dictated by the size, hardness, and amount of filler, which influence the mechanical properties of the composite resins, and by the flexibility of the backing material and hardness and grit size of the abrasive.[5,7]

The resin matrix and the filler particles of composite resins do not abrade to the same degree due to different hardnesses. For instance, craters are often formed around hard quartz particles of conventional composite resins after polishing. As a consequence, irregularities appear on the surface of the restorations. The filler content of the composite resin also affects roughness, as microfilled composite resins show smoother surfaces than hybrid composite resins. Similarly, the resin matrix composition may also play a role in the final smoothness of the restoration.[7]

For composite resins, the smoothest surfaces were produced when the materials were allowed to polymerize against a matrix.[1,8,12] Despite careful placement of the matrix, removing excess material and recontouring restorations is often clinically necessary. This requires some degree of finishing and polishing, which may alter the smoothness obtained with a matrix.[8] Finishing instruments have been designed to produce a smooth surface on dental restorative materials. Instruments commonly used for finishing and polishing tooth-colored restorative materials include carbide burs, 25- to 50-μm diamond rotary cutting instruments, abrasive impregnated rubber cubs and points, abrasive discs, strips, and polishing pastes.[7,13,14] The flexibility of the backing material in which the abrasive is embedded, the hardness of the abrasive, and the grit size influence surface roughness.[7] For composite resins, polymerizing against a matrix results in the smoothest surface possible.[5] Ra values after treatment with the various finishing/polishing systems were generally greater than the critical threshold surface roughness for bacteria adhesion, 0.2 μm.[1,15]

The use of unfilled resins for covering composite resins was first suggested 20 years ago. These were autopolymerized resins with bis-GMA matrix, called glazes, and were primarily recommended to improve the optimal properties of composite resin restorations.[16,17] Various surface defects can appear, such as microcracks and irregularities due to removal of some of the surface particles during finishing. With the purpose to fill in these microstructural defects and to improve the resistance to abrasion of posterior composite resins, application of liquid resin to the surface of the material after finishing has been recommended.[16-18] The studies of glazes have shown advantageous effects on the surface texture of composite resin restorations.[16,18,19] Nevertheless, disadvantages of these materials were reported also. Takeuchi et al[17] evaluated the effect of glaze material on the surface roughness of a posterior composite resin before and after tooth brushing. The authors reported that the use of glaze materials did not effectively prevent the surface roughness of a posterior composite resin after simulated tooth brushing.[17] In another investigation, the effect of a glaze material on staining resistance of the composite resin surface was evaluated, and it was determined that the polymerization duration and the content of the glaze material affects the staining resistance.[20] Glaze materials containing methacrylate or dimethacrylate resins are more resistant to staining than ethoxylated bisphenol A dimethacrylate component.[20]

Optical properties of the dental composite resins were influenced by surface changes during restorative procedures of finishing and polishing.[21] Color change (ΔE) mathematically expresses the amount of difference between the L*a*b* coordinates of different specimens or the same specimen at different instances.[22] The Commission Internationale de l'Eclairage (CIE) L*a*b* color system, which is related to the color perception of the human eye for 3 coordinates, is an approximately uniform color space with coordinates for lightness, namely white-black (L*), red-green (a*), and yellow-blue (b*).[23] Various studies have reported different thresholds of ΔE values above which the color change is perceptible to the human eye. These values ranged from ΔE equal to 1,[24,25] greater than or equal to 3.3,[26-29] and greater than or equal to 3.7.[30] Values of ΔE in the range of 2 to 3 were perceptible, values from 3 to 8 were moderately perceptible, and values above 8 were markedly perceptible.[31] A ΔE value of 3.7 or less is considered to be clinically acceptable according to Johnston and Kao.[30]

A spectrophotometer with an integrating sphere can operate at 2 different measuring geometries—the specular component included (SCI) geometry, and the specular component excluded (SCE) geometry.[32] Lee et al[32] stated that the surface condition, especially roughness, of materials should be kept constant during color measurements. If that proves too difficult, the SCE geometry rather than the SCI geometry would reflect the changes in surface condition.[32]

In dental color measurement, results of a photometric device can be inaccurate because the illuminating light emitted from the device can be scattered, absorbed, transmitted, reflected, and displaced as a result of the translucent optical properties and varied surface conditions of teeth and corresponding dental restorative materials.[33] Since there are no accepted standards for surface roughness and gloss for human tooth enamel,

Table I. Materials used in this study

Material	Product	Code	Batch no.	Manufacturer
Nanohybrid composite resin (inorganic filler ratio: 87% of weight, 71,4% of the volume)	Grandio	N	501435	VOCO, Cuxhaven, Germany
Microhybrid composite resin (inorganic filler ratio: 78% of weight, 61% of the volume)	Filtek Z250	M	5JJ	3M ESPE, St Paul, Minn
Hybrid composite resin (inorganic filler ratio: 75% of weight, 60% of volume)	Quadrant Universal LC	H	S010113C	Cavex Holland BV, Haarlem, The Netherlands
Aluminum oxide abrasive discs	Sof-Lex disk	D	P021126	3M ESPE
Polishing wheel system	Astropol	W	H22742	Ivoclar Vivadent, Schaan, Liechtenstein
Glaze material	Biscover	G	0400002853	Bisco, Schaumburg, Ill

there are no data on desirable surface roughness and gloss of restorative dental materials.[34] These 2 parameters were found to be inversely related; namely, when surface roughness increases, gloss decreases. [34] It has been reported that shades of the tested dental composite resins polished sequentially by a series of silicone carbide papers and evaluated colorimetrically were observed to become lighter than those of the shade guides.[35] The tristimulus color values and gloss of composite resins were significantly changed after polishing with silicone carbide papers.[36]

With a highly glazed surface, the restoration becomes more translucent, and the color hue changes toward yellow-orange. Often a dentist is satisfied with the choice of shade selected from a shade guide, but finds that the completed restoration does not match as well as expected, especially after finishing and polishing. In general, polished composite resins tend to appear lighter, whiter, and less glossy than the corresponding matrix covered surfaces.[32] The objective of this study was to evaluate the effect of polishing techniques on the Ra and ΔE values of 3 composite resin materials. The research hypothesis was that significantly different Ra and ΔE values would be found for different polishing techniques tested.

MATERIAL AND METHODS

In this study, 3 light-polymerized composite resins (Shade A3) with different sized filler content (a nanohybrid, a microhybrid, and a hybrid composite resin), 2 polishing systems, and a glaze material were used (Table I). Fifty disc-shaped specimens were prepared for each composite resin material (10 × 2 mm), for a total of 150 specimens, using a plastic transparent mold with a hole in the center (10 mm in diameter and 2 mm in height). The plastic mold was placed onto a glass plate with a polyester matrix over it. The composite resin was placed into the mold, and then another polyester matrix and a glass plate were placed onto the composite resin surface. The glass plate was pressed until it had a tight contact with the plastic mold. Then the composite resin material was light polymerized for 20 seconds with a quartz tungsten halogen (QTH) polymerizing light (Astralis 3; Ivoclar Vivadent, Schaan, Liechtenstein) with an output of 600 mW/cm^2. After polymerization, the specimens were stored in distilled water at 37°C for 24 hours. Specimens of each composite resin were divided into 5 groups, each containing 10 specimens.

A group for each composite resin served as the control group (Group C), and specimens received no treatment. In the experimental groups the composite resin surfaces of the specimens were grounded with a 1000-grit silicon carbide paper (Carbimet; Buehler, Lake Bluff, Ill). The specimens in Group D were polished sequentially with medium, fine, and superfine aluminum oxide abrasive discs (Sof-Lex; 3M ESPE, St Paul, Minn) for 30 seconds; Group W specimens were polished with a polishing wheel system (Astropol; Ivoclar Vivadent and Diagloss Axis Dental, Irving, Tex) for 30 seconds; Group DG specimens were polished with aluminum oxide abrasive discs preceding a glaze (Biscover; Bisco Inc, Schaumburg, Ill) application; Group WG specimens were polished with a polishing wheel system preceding the glaze application. The abrasive discs and polishing wheels were used with a slow-speed hand piece (NBBW-E; Nsk Nakanishi Inc, Tochigi, Japan), rotating at approximately 20,000 rpm with water cooling. In Group DG and WG, before the application of glaze material, the surfaces of composite resin specimens were etched with 32% phosphoric acid (UNI-ETCH; Bisco Inc) for 15 seconds. Then the specimens were rinsed with water and air dried. Subsequently, the glaze material was applied directly, using a syringe and an applicator tip, and light polymerized for 30 seconds. Polyester matrix strips, abrasive discs, and polishing wheels were discarded after each use. The specimens were stored in distilled water at 37°C for 24 hours. Polishing was performed by the same investigator (10,000 rpm) until the surface

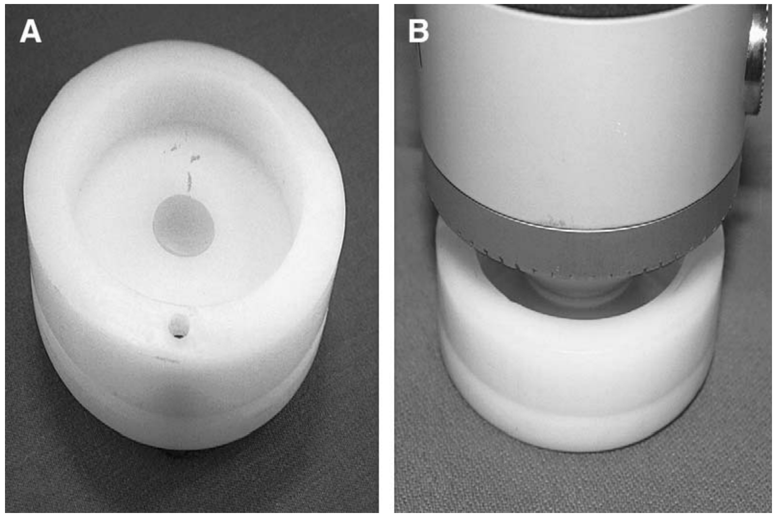

Fig. 1. Custom-made mold prepared for colorimetric measurements. **A,** Specimen placed into mold. **B,** Use of mold while colorimetric measurement was performed.

appeared shiny to the naked eye, simulating clinical procedures.

After these procedures, the color measurements of the specimens were made using a small area colorimeter (CR-300; Minolta, Osaka, Japan). Three colorimetric measurements were made for each specimen, and the mean CIE L*a*b* values were recorded. To position the tip of the colorimeter to the same area of the specimens, a white custom-made mold made of polytetrafluoroethylene was prepared (Fig. 1), and with the use of this mold, the background color of the specimen was white. The colorimeter was calibrated according to manufacturer's instructions before each measurement period, using the white calibration cap (CR-A43; Minolta) supplied by the manufacturer. The quantitative ΔE values between the specimens of Group C and the experimental groups were calculated with the following formula[29,32,34]:

$$\Delta E = [(L^*_E - L^*_C)^2 + (a^*_E - a^*_C)^2 + (b^*_E - b^*_C)^2]^{1/2}$$

where $(L^*_E - L^*_C)$, $(a^*_E - a^*_C)$, and $(b^*_E - b^*_C)$ are the differences in ΔL^*, Δa^*, and Δb^* values, respectively. E represents the experimental specimens, and C represents the control specimens. The ΔE values were analyzed statistically by 2-way analysis of variance (ANOVA) and a Tukey multiple comparisons test (α=.05).

After colorimetric evaluation, surface roughness of the specimens was evaluated using a profilometer (Surf Test 402 Analyzer; Mitutoyo Co, Kawasaki, Japan). To measure the roughness profile value, the diamond stylus (5-μm tip radius) was moved across the surface under a constant load of 3.9 mN. The instrument was calibrated using a standard reference specimen, then set to travel at a speed of 0.100 mm/s with a range of 600 μm during testing. The surface analyzer was used to determine the roughness profile of each specimen. This procedure was repeated 3 times for all specimens, and the average value was considered to be the Ra value. The data were analyzed by 2-way ANOVA followed by a Tukey multiple comparisons test (α=.05). The colorimetric and profilometric analyses were performed using the same specimens. Because the effect of time and environment (temperature, humidity, and light) during the profilometric analysis on the color change of the specimens could not be known, a separate control group was used to compare the color difference of the composite resins rather than comparing the color of the disc prior to finishing and polishing to its color after finishing and polishing.

Table II. Two-way ANOVA results for comparison of Ra values

Source of variation	Sum of squares	*df*	Mean square	F	*P*
Composite resin	4.780	2	2.390	623.33	.001
Polishing technique	18.482	4	4.620	1205.04	.001
Composite resin × Polishing technique	3.644	8	.455	118.79	.001
Error	.518	135	.004		
Total	125.579	150			

RESULTS

The result of the 2-way ANOVA used to test the surface roughness of the composite resins showed that the type of composite resin, polishing technique, and their interactions were statistically significant (P<.001) (Table II). The mean Ra values, SDs, and differences within groups of the composite resins according to the type of composite resin are listed in Table III. The differences within groups of the composite resins according to the polishing technique are shown in Table IV.

Table III. Mean (SD) Ra values and differences within groups for each composite resin according to type of composite resin

	N	M	H
Group C (Control)	0.37 (0.04)	0.46 (0.08)	0.51 (0.06)
Group D	0.79 (0.04)	0.82 (0.05)	1.60 (0.07)
Group W	0.96 (0.06)	1.30 (0.10)	1.83 (0.08)
Group DG	0.47 (0.05)	0.52 (0.04)	0.58 (0.05)
Group WG	0.53 (0.05)	0.66 (0.05)	0.73 (0.07)

Connecting bars indicate no significant differences (P>.05).

Table IV. Mean (SD) Ra values and differences within groups for each composite resin according to polishing techniques

	N	M	H
Group C (Control)	0.37 (0.04)	0.46 (0.08)	0.51 (0.06)
Group D	0.79 (0.04)	0.82 (0.05)	1.60 (0.07)
Group W	0.96 (0.06)	1.30 (0.10)	1.83 (0.08)
Group DG	0.47 (0.05)	0.52 (0.04)	0.58 (0.05)
Group WG	0.53 (0.05)	0.66 (0.05)	0.73 (0.07)

Connecting bars indicate no significant differences (P>.05).

Table V. Two-way ANOVA results for comparison of ΔE values

Source of variation	Sum of squares	*df*	Mean square	F	*P*
Composite resin	3.2	2	1.60	105.58	.001
Polishing technique	8.9	3	2.97	195.36	.001
Composite resin × Polishing technique	1.2	6	.20	13.09	.001
Error	1.6	108	.02		
Total	377.7	120			

Table VI. Mean (SD) ΔE values and differences within groups for each composite resin according to type of composite resin

	N	M	H
Group D	1.66 (0.06)	1.83 (0.10)	2.30 (0.17)
Group W	1.78 (0.11)	2.00 (0.18)	2.39 (0.17)
Group DG	1.25 (0.8)	1.38 (0.10)	1.46 (0.08)
Group WG	1.52 (0.06)	1.63 (0.14)	1.66 (0.14)

Connecting bar indicates no significant difference (P>.05).

When the polishing techniques were compared, the highest Ra values were obtained with the specimens polished with polishing wheels (Group W) for each composite resin (P<.001). The nanohybrid composite resin displayed the lowest Ra value with the control specimens (P<.001). No significant difference was found between Group DG and WG. For microhybrid and hybrid composite resins, although control specimens showed lower Ra values than the other groups, there was no significant difference between the control group and Group DG (Table III).

When the types of composite resin were compared, the lowest Ra value for control groups was obtained with nanohybrid composite resin (P<.001), and no significant difference was found between microhybrid and hybrid composite resins. Group D and DG specimens demonstrated the highest Ra values with the hybrid composite resin (P<.001), and there was no significance between nanohybrid and microhybrid composite resins. For Group W and WG specimens, all composite resins were found to be significantly different from each other (P<.001).

The results of the 2-way ANOVA used to test the ΔE values for differences among the groups are shown in Table V. The type of composite resin, polishing technique, and their interaction were significant (P<.001). When the effect of polishing technique on the color difference of the composite resins was investigated for nanohybrid and microhybrid composite resins, all polishing techniques were found to be significant from each other (P<.001). While the lowest ΔE values were obtained with Group DG, the highest ΔE values were obtained with Group W (P<.001) (Table VI). For hybrid composite resin specimens, Group DG presented the lowest ΔE value (P<.001), and no significant difference was found between Group W and D (Table VI).

When the effects of type of composite resin on the color difference of the composite resins were compared, Group D and W presented the lowest ΔE values for the nanohybrid composite resin (P<.001) and the highest ΔE values for the hybrid composite resin (P<.001). For Group DG specimens, the lowest Ra value was obtained with nanohybrid composite resin (P<.001), and no significant difference was found between microhybrid and hybrid composite resins. There were no significant differences between the composite resins in Group WG (Table VII).

DISCUSSION

The hypothesis of this study was that the polishing technique and filler content of the composite resin would affect surface roughness and color change. The results of this study support the research hypothesis. Significant differences were found in Ra (P<.001) and ΔE values (P<.001) among the groups. Previous studies have shown that the smoothest obtainable surface of resin composite resin restorations is achieved by polymerizing the material in direct contact with a smooth polyester matrix surface.[1,2,11] In the present study, the Ra values of the control specimens for all composite resins, which were polymerized in direct contact with a

Table VII. Mean (SD) ΔE values and differences within groups for each composite resin according to polishing techniques

	N	M	H
Group D	1.66 (0.06)	1.83 (0.10)	2.30 (0.17)
Group W	1.78 (0.11)	2.00 (0.18)	2.39 (0.17)
Group DG	1.25 (0.8)	1.38 (0.10)	1.46 (0.08)
Group WG	1.52 (0.06)	1.63 (0.14)	1.66 (0.14)

Connecting bars indicate no significant differences ($P>.05$).

polyester matrix surface, were found to be lower than the other groups polished with different polishing techniques.

The use of surface-penetrating sealant or glaze material after polishing discs or polishing wheels resulted in significant lower Ra values than the use of polishing discs or polishing wheels alone ($P<.001$). The glaze material may fill the structural microdefects and microfissures by capillary actions, which are formed during the insertion techniques and finishing/polishing procedures. This method may provide a more uniform, regular surface, thereby enhancing surface smoothness.[17] In the present study, the application of the glaze material decreased surface roughness and color change. However, even though the glaze material is resistant to function, tooth brushing, and staining, initially, some investigations demonstrated a degradation of the glaze material as it ages.[17,20]

In the present study, polishing discs created smoother surfaces than polishing wheels. In a similar study, it was reported that lowest Ra values were obtained with the specimens polymerized against the polyester matrix group and, while the aluminum oxide abrasive disc group showed the lower Ra values than the other groups polished with different polishing techniques, the highest Ra values were obtained with the use of polishing wheels.[12] To be an effective finishing system for composite resin, the abrasive particles must be relatively harder than the filler materials. Otherwise, the polishing agent will only remove the soft resin matrix and leave the filler particles protruding from the surface.[7] The hardness of aluminum oxide is significantly higher than that of silicone oxide and, generally, higher than most filler materials used in composite resin formulations.[7] As a result, aluminum oxide abrasive discs created smoother surfaces than polishing wheels.

When the effect of filler content of the composite resins on the surface roughness was evaluated, the Ra values of different composite resin materials were significantly different compared to each other ($P<.001$). The hybrid composite resin showed higher Ra values than microhybrid and nanohybrid composite resins. In composite resins, in which the fillers are markedly harder than the resin matrix, the resin phase may suffer a preferential loss during finishing and polishing, leaving the filler phase in positive surface relief.[5] In several studies, it was also reported that larger filler-particle size resulted in greater Ra values.[13,34] Use of composite resins with a higher small-sized filler-particle content has increased in recent years, due to difficulties in producing smooth surfaces such as enamel with the composite resins, which have larger filler particles. An increase in the amount of filler content results in smoother surfaces because of decreased particle size and better distribution within the resin matrix.[7]

When the ΔE values were compared, significant differences were found between the composite resin materials, which had different sizes and different amounts of filler content ($P<.001$). Also, polishing techniques affected the ΔE values ($P<.001$). This effect is thought to be related to the surface morphology. Optical properties of dental composite resins are directly affected by surface roughness.[32] An increasingly roughened surface will reflect the individual segment of the specular beam at slightly different angles. Lee et al[32] investigated the effect of color measuring geometry of SCE and SCI on the color of composite resin of different conditions with the use of a spectrophotometer. The authors reported that color measuring geometry influenced the color measurement of composite resins with different surface roughness. If the surface configuration had a matte finish, there would be an excessive amount of light reflected at surface level and a reduction of light transmission through the material. Surface texture controls the degree of scattering or reflection of the light striking on the natural tooth or the material.[32] For this reason, clinicians experience problems in establishing harmony of the shade obtained with the original shade that was selected using a shade guide, especially after finishing and polishing procedures.[32]

Color difference (ΔE) values obtained with different polishing techniques in this study are ranked in an ascending order: (1) polishing wheels followed by application of glaze material, (2) polishing discs followed by application of glaze material, (3) polishing wheels, and (4) polishing discs. A significant decrease was observed in Ra values as well as the ΔE values by the application of a glaze material.

When composite resins with different sized filler particles were compared, higher ΔE values were obtained with the hybrid composite resin than other composite resins tested. It was reported that increased particle size resulted in lower amounts of color changes due to a decrease in the proportion of organic filler matrix, resulting in a decrease in the rate of fluid absorption.[34] In this study, fluid absorption or dissolution was not considered, as the composite resin specimens were not stored in any type of fluid. Only the effects of polishing procedures on color stability were investigated. Color differences among composite resins were related to the size of filler particles exposed on the surfaces following polishing procedures. The degree of surface roughness after polishing increases with the increase in filler particle size, and the amount of light reflection also changes accordingly. Consequently, an increase in the size of filler particles would result in surface irregularities, causing a difference in color. Furthermore, Lee et al[32] stated that the SCE measuring geometry reflected the influence of surface roughness on the measured color more accurately. In this study, the arrangement of ΔE values in ascending order is nanohybrid, microhybrid, and hybrid composite resins, which is similar in order to the inorganic filler particle sizes. The color differences among 3 composite resin materials and 4 polishing methods tested were found to be between 1.02 and 2.55 in this study. Although polishing methods showed statistically significant color differences, these differences are within a clinically acceptable level, as they are below 3.7.

This in vitro study has several limitations. Only 4 polishing techniques and 3 composite resin materials with different sized filler contents were used, and the specimens were not stored in a humid environment. To compare the color difference of the polished discs, a separate control group was preferred, rather than comparing the color of the disc prior to finishing and polishing with its color after finishing and polishing for profilometric and colorimetric analyses. Different results may be obtained with different polishing techniques and composite resin materials. Therefore, further investigation is necessary to evaluate the surface roughness and color change of different composite resin materials before and after polishing with different polishing techniques.

CONCLUSION

Within the limitations of this in vitro study the following conclusions were drawn:

1. Significant differences were found in the surface roughness and color change with the different polishing techniques and composite resin materials evaluated ($P<.001$).
2. The highest Ra and ΔE values were obtained with hybrid composite resins, likely due to the size of the filler particles that were exposed after polishing ($P<.001$).
3. The use of glaze material after polishing discs and polishing wheels decreased the surface roughness and color change significantly ($P<.001$).

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