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Original Research

Influence of Surface Sealants on the Roughness and Staining of Composite Resins

Influência de Selantes Superficiais na Rugosidade e no Manchamento de Resinas Compostas
Influencia de los Selladores Superficiales en la Rugosidad y la Tinción de las Resinas Compuestas

Rodrigo Vieira **CAIXETA**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0003-3055-5093
Amanda Suéllen Giacomini dos **SANTOS**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
Jéssika Hoffer **CONSORTE**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
Marcela **POLAY**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
Luy de Abreu **COSTA**
Faculty of Dentistry UNESP (FOA), Araçatuba, Brazil
https://orcid.org/0000-0003-3661-8219
David Jonathan Rodrigues **GUSMAN**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0003-0071-1630
Fábio Hideo **KAIAHARA**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0002-4353-8148
Bruno Carrino **SUAVE**
Health Biotechnology Research Laboratory (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0003-1072-7644
Carolina **SANTINONI**
Federal University of Santa Catarina (UFSC), Florianópolis, Brazil
https://orcid.org/0000-0001-5153-2419
Anderson **CATELAN**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0002-5916-8655
Fellippo Ramos **VERRI**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0001-5688-1669
Christine Men **MARTINS BATISTA**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil
https://orcid.org/0000-0002-5429-509X
Victor Eduardo **DE SOUZA BATISTA**
School of Dentistry, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, Brazil,
Faculty of Dentistry UNESP (FOA), Araçatuba, Brazil
https://orcid.org/0000-0003-0246-8101

Abstract

Objective: To evaluate the surface roughness and staining of two types of composite resins after application of different sealants and to assess the performance of VLB (low-viscosity sealant). Materials and methods: Two types of composite resins, a finishing/polishing system, and two types of surface sealants were used. Eighty test specimens were prepared and randomly distributed into eight groups according to the material and treatment: GZ and GX (controls); GZS; GZF; GZV; GXS; GXF; GXV. Initial color readings were performed using a spectrophotometer, and surface roughness (Ra) was measured with a portable profilometer. Specimens were immersed in a refrigerant for 2 hours daily for 40 days, then subjected to color and roughness readings again. Results: The control groups GZ (Ra=0.30) and GX (Ra=0.39) had higher surface roughness compared to all other groups in both initial and final conditions. The Fortify sealant (Ra=0.13) and the VLB sealant (Ra=0.16) produced similar and better surface roughness values than groups without sealant treatment (Ra=0.29). The control groups GZ=3.49 and GX=3.58 showed clinically unacceptable color change (ΔE above 3.3), while the other groups had clinically acceptable results (1<ΔE<3.3). Conclusion: The nanoparticulate composite resin had better surface smoothness than the bulk-fill hybrid resin. The sealants showed similar performance in terms of roughness and staining. The finishing/polishing and the sealants helped maintain surface roughness after immersion in refrigerant. Staining occurred in the composite resins in all groups; however, only the control groups (GZ and GX) were not clinically acceptable.

Descriptors: Polishing; Sealants; Composite Resins; Surface Properties.

Resumo

Objetivo: Avaliar a rugosidade e o manchamento de superfície de dois tipos de resinas compostas após aplicação de diferentes selantes e verificar o desempenho do VLB. Material e métodos: Foram utilizados dois tipos de resinas compostas, um sistema de acabamento/polimento e dois tipos de selantes superficiais. Os 80 corpos de prova foram confeccionados e distribuídos aleatoriamente em 8 grupos, conforme o material e tratamento realizado: GZ e GX (controles); GZS; GZF; GZV; GXS; GXF; GXV. Foi realizada a leitura da cor inicial utilizando espectrofotômetro e leitura da rugosidade superficial (Ra) utilizando um rugosímetro portátil. Foram imersos em refrigerante por 2 horas durante 40 dias e submetidos novamente às leituras da cor e rugosidade. Resultados: Os grupos controles GZ (Ra=0,30) e GX(Ra=0,39) tiveram médias com pior lisura superficial comparado a qualquer outro grupo na condição inicial e final. O selante Fortify (Ra=0,13) e o selante VLB (Ra=0,16) tiveram valores de rugosidade superficial semelhantes e melhores que os grupos que não receberam este tratamento (Ra=0,29). Os grupos controles GZ=3,49 e GX=3,58 tiveram resultados não aceitáveis clinicamente quanto à alteração de cor (ΔE acima de 3,3), enquanto os demais grupos apresentaram-se clinicamente aceitáveis (1<ΔE<3,3). A resina composta nanoparticulada teve melhor lisura superficial comparada à resina híbrida Bulk fill e os selantes tiveram desempenhos semelhantes. O acabamento/polimento e os selantes melhoraram a rugosidade superficial inalterada após imersão em refrigerante. Todos os grupos mancharam e apenas os grupos controles (GZ e GX) não foram aceitáveis clinicamente.

Descritores: Polimento; Selantes; Resinas Compostas; Propriedades de Superfície.

Resumen

Objetivo: Evaluar la rugosidad superficial y la tinción de dos tipos de resinas compuestas después de la aplicación de diferentes selladores y analizar el desempeño del VLB (sellador de baja viscosidad). Materiales y métodos: Se utilizaron dos tipos de resinas compuestas, un sistema de acabado/pulido y dos tipos de selladores superficiales. Se prepararon ochenta especímenes de prueba y se distribuyeron aleatoriamente en ocho grupos según el material y el tratamiento: GZ y GX (controles); GZS; GZF; GZV; GXS; GXF; GXV. Se realizaron lecturas iniciales de color con un espectrofotómetro y la rugosidad superficial (Ra) se midió con un perfilómetro portátil. Los especímenes se sumergieron en un refrigerante durante 2 horas diarias por 40 días, y posteriormente se sometieron nuevamente a lecturas de color y rugosidad. Resultados: Los grupos control GZ (Ra=0.30) y GX (Ra=0.39) presentaron mayor rugosidad superficial en comparación con todos los demás grupos, tanto en condiciones iniciales como finales. El sellador Fortify (Ra=0.13) y el sellador VLB (Ra=0.16) produjeron valores similares y mejores de rugosidad superficial que los grupos sin tratamiento con sellador (Ra=0.29). Los grupos control GZ=3.49 y GX=3.58 mostraron un cambio de color clínicamente inaceptable (ΔE superior a 3.3), mientras que los demás grupos tuvieron resultados clínicamente aceptables (1<ΔE<3.3). Conclusión: La resina compuesta nanoparticulada presentó mejor suavidad superficial que la resina híbrida bulk-fill. Los selladores mostraron un desempeño similar en términos de rugosidad y tinción. El acabado/pulido y los selladores ayudaron a mantener la rugosidad superficial después de la inmersión en refrigerante. La tinción ocurrió en las resinas compuestas en todos los grupos; sin embargo, solo los grupos control (GZ y GX) no fueron clínicamente aceptables

Descriptores: Pulido; Selladores; Resinas Compuestas; Propiedades de Superficies.

INTRODUCTION

Composite resins have become the material of choice for restorations because they offer better aesthetics and allow for more conservative preparations. Composite resin restorations can restore the color, shape, and function of teeth, provided they are performed according to technical criteria. Finishing and polishing also enhance the aesthetics and function of restorations by creating contours and textures that closely resemble the natural anatomy of the dental crown[1-3].

Direct composite resin restorations are more conservative than amalgam and indirect restorations. Improvements in the physical and mechanical properties of composite resins over time – including modifications to their organic matrices, the type and size of filler particles, increased degree of polymerization, and the development of nanotechnologies – have advanced this material and increased confidence in its use[4,5].

Without proper finishing and polishing of composite resin restorations, issues such as stains, biofilm accumulation, gingival irritation, recurrent caries, increased susceptibility to abrasion, and discoloration can arise, all of which compromise the longevity of these restorations.[2,6,7] The ideal timing for finishing and polishing composite resin restorations remains controversial, as immediate polishing may initially compromise the marginal seal of the restoration[7,8].

Professionals should be familiar with the different compositions of composite resins and the techniques used for finishing and polishing, since the size, morphology, and type of filler particles, as well as the instruments used, can influence the results. Composite resin surfaces can be scratched by finishing and polishing procedures intended to remove small excesses, smooth the surface, and improve anatomy with adequate light reflection. These procedures can be performed with rubber points, diamond burs, sanding discs of varying abrasiveness, and polishing pastes, providing the surface with a shine and texture similar to enamel so that the restoration is as imperceptible as possible[9-11].

Another important consideration is that restorations without adequate polymerization can result in a softer surface and, consequently, a greater tendency to retain scratches created by finishing and polishing procedures.[12,13] Several studies have shown that using flexible aluminum oxide discs in a graduated abrasiveness sequence and polishing discs produces smoother and softer surfaces[1,2,14-16].

The literature also suggests applying a surface sealant after finishing and polishing procedures to increase the longevity of restorations. This material should cover the entire surface of the restoration and extend 1 mm beyond its margins to help maintain marginal integrity and improve the surface quality of the restorative material. Surface sealants help eliminate microcracks, reduce roughness, improve wear resistance, and minimize the adverse effects of acidic substances, including bleaching agents, on the surface hardness of composite resin[17-20].

Biofilm adhesion to dental restorations and structures is related to the surface roughness of the restorative material. Even clinical prophylaxis procedures with a sodium bicarbonate jet or rubber cup and pumice stone generate rougher surfaces on composite resins, and repolishing followed by sealant application on these surfaces can make them smoother and hinder this adhesion.[21,22] On the other hand, coloration can be influenced by the chemical structure and size or type of composite material particles. The hydrophilic resin matrix can increase water absorption by the polymer network, resulting in discoloration (a whiter and more opaque tone). However, if the resin matrix is hydrophobic, there will be less water absorption and little change in color tone[23].

Finishing and polishing materials and sealing agents have been developed to fill surface defects and irregularities to prevent microleakage, improve marginal sealing, increase wear resistance, and improve stain resistance.[20,24] Factors that can influence the appearance of stains in different types of composite resin have been investigated and reported in the literature. Several types of liquids, such as coffee, tea, wine, and Coca-Cola®, can significantly influence the staining of these materials, especially when surface roughness is increased.[25,26] Thus, composite resin restorations should be preserved to maintain smooth surfaces and increase stain resistance.[2,25,27] Composite resins can have their color stability affected by intrinsic factors such as the choice of material, matrix properties, and matrix/filler interface, as well as extrinsic factors that contaminate these materials (exogenous sources) such as food, beverages, and tobacco, which can cause varying degrees of staining.[28,29,30]

In this study, we aimed to verify the behavior of a natural nanotechnology product composed of silicon dioxide (SiO_2), which is non-toxic and ecologically sustainable. According to the manufacturer, it provides invisible protection to a plastic surface for up to 12 months. This product, VLB - Universal (Vidro Líquido Brasil), claims that the coated surface does not change color and prevents bacterial growth, making it relevant to compare with a surface sealant used in dentistry.

The clinical relevance of this in vitro study is justified because applying a sealant to the surface of composite resin after fabricating an esthetic restoration can improve surface texture, inhibit staining, and enhance clinical performance, thereby increasing its longevity.

The objective of this study was to evaluate the surface roughness and staining of two types of composite resins after the application of different sealants and to assess the performance of VLB.

MATERIAL AND METHOD

This in vitro laboratory study evaluated the surface roughness of two composite resins, a finishing and polishing system, and two types of surface sealants, as shown in Table 1. The study was conducted in the research laboratory of the Faculty of Dentistry of Presidente Prudente at Unoeste.

Table 1 – Materials used, finishing, and polishing system.

Brand	Material	Manufacturer	Composition
Filtek™ Z350 XT	Composite resin	3M Brazil	BIS-GMA, BIS-EMA, UDMA, TEGDMA, Silica and zirconia/silica nano-agglomerate. 78.5% by weight.
x-tra fil	Composite resin	VOCO América	Bis-GMA, UDMA, TEGDMA. 86% by weight
Fortify	Surface sealant	Bisco (Schaumburg, IL, USA)	Urethane dimethacrylate, Bisphenol A,dimethacrylate Ethoxylated
VLB líquid	Surface sealant	VLB (BH, MG, Brazil)	Silicon dioxide (purest form)
Sof-Lex	Abrasive discs	3M ESPE (St. Paul, Min, USA)	Aluminum oxide
Diamond Flex	Felt disc	FGM (Joinvile, SC, Brazil)	Polyester and aluminum oxide
Diamond Excel	Polymer paste	FGM (Joinvile, SC, Brazil)	Micronized diamond + thickener

Source: Survey Data

Nanoparticulate resin and Bulk Fill resin have mechanical properties suitable for use in both anterior and posterior teeth. The universal shade, light-cured x-tra fil Bulk Fill resin can be placed in layers up to 4 mm, while the nanoparticulate resin is placed in layers up to 2 mm, with shade A3 selected. The sealants used in this study were: Fortify, a low-viscosity, light-cured flowable resin formulated for use as a surface sealant for direct and indirect composite resin restorations and as a sealant for temporary restorations; and VLB liquid sealant, a single-component, ready-to-use sealant with natural nanotechnology that forms a molecular glass barrier on stain-resistant, easy-to-clean plastic surfaces. It stabilizes within minutes of application and completes curing after 24 hours. It is odorless, clear to cloudy, and safe for contact with food and skin.

For the preparation of the test specimens, nylon molds were fabricated and individually customized to include a central cylindrical cavity measuring 5 mm in diameter, 2 mm in height, and 12 mm in overall diameter. Each mold was positioned in a stainless-steel die holder, designed as a truncated cylinder with a central circular depression corresponding to the die's diameter and a depth of 2 mm. This 1 mm depression was aligned with the central cavity of the matrix to ensure proper adaptation. Each specimen, standardized at 5 mm in diameter and 3 mm in height, was prepared as follows: with the matrix properly adapted to the holder, the restorative material was inserted up to the surface limit. To minimize porosity, the material was placed in increments of 1.5 mm and condensed using a Thompson No. 2 spatula. Polymerization was performed with the Poly Wireless photopolymerization unit (Kavo), applying light at an intensity of 1,100 mW/cm² for 40 seconds per increment.

A total of eighty specimens were prepared. Each specimen, along with its respective mold, was removed from the holder, properly identified, and stored in distilled water at 37 ± 1 °C in a bacteriological incubator for 24 hours. Following this period, the specimens were randomly allocated into eight experimental groups (n = 10), as detailed in Table 2.

Table 2 – Distribution of groups.

Groups	Material	Type of treatment
GZ	Filtek™ Z350 XT	Control or none at all
GZS	Filtek™ Z350 XT	Sof-Lex + paste (finishing/polishing only)
GZF	Filtek™ Z350 XT	Sof-Lex + paste + Fortify
GZV	Filtek™ Z350 XT	Sof-Lex + paste + VLB
GX	x-tra fil	Controlo or none at all
GXS	x-tra fil	Sof-Lex + paste (finishing/polishing only)
GXF	x-tra fil	Sof-Lex + paste + Fortify
GXV	x-tra fil	Sof-Lex + paste + VLB

Source: Survey Data

A bacteriological incubator calibrated at 37°C ± 1°C was used to store the test specimens from all groups for 24 hours at two different times: 1) immediately after the preparation of each specimen, and 2) after the specific treatment for each group. Thus, all groups were stored for a total of 48 hours before surface roughness (Ra) was measured. Even the control groups, GZ and GX, which did not require treatment, remained in the bacteriological incubator for 48 hours. The GZS and GXS groups received the finishing/polishing treatment after 24 hours in the incubator and were then returned to the incubator for another 24 hours before roughness measurement. The same procedures were followed for the GZF, GZV, GXF, and GXV groups; however, the surface sealant was applied to these immediately after finishing/polishing. These two 24-hour periods were chosen to ensure better stability of the composite resins and because the VLB sealant stabilizes in 2 to 3 minutes, but its cure is complete after 24 hours. Therefore, it was preferred to wait this time before performing the roughness measurement, a period that was also standardized for all other groups.

For the finishing/polishing process, the specimens were placed back in the die holder in an inverted position to expose the 1 mm overhanging portion. Finishing and polishing were performed by a single trained operator following the manufacturer's recommendations. With each change of discs of different grit sizes, the specimen was thoroughly washed and dried with a water/air jet from the triple syringe. Three discs mounted on a handpiece at low speed with cooling were used in a decreasing sequence of abrasiveness across the entire surface of the specimen for 20 seconds. After every two specimens, the discs were discarded and replaced with new ones. After using the Sof-Lex discs, aluminum oxide diamond paste was applied to the specimen surfaces with felt discs for 20 seconds, and each specimen was thoroughly rinsed to remove surface residue and dried with a light blast of air from a triple syringe.

The specific surface sealant was applied to each group with a microbrush, following the manufacturer's recommendations and using a light blast of air for approximately 3 seconds to better distribute the product on the surface. The light-cured sealant was activated for 20 seconds. Immediately afterward, the specimens were kept in a bacteriological incubator for 24 hours to undergo initial color evaluation (L-a-b values) and initial surface roughness (Ra) measurement using a Hommel-Etamic T1000 portable profilometer.

Three readings were taken after rotating approximately 120 degrees using a protractor to ensure measurements from three different areas on the surface of each test specimen. The probe tip was positioned parallel to the surface of the test specimen and traversed it diametrically with a 0.25 mm cutoff, at a speed of 0.05 mm/s, and a sampling length of 2.5 mm.

The initial surface roughness results for each reading were obtained in μm as the average surface roughness (Ra), representing the mean size of the peaks and valleys detected by the probe tip as it traversed the specimen's surface.

Color was evaluated with the VITA Easyshade instrument (Wilcos do Brasil Indústria e Comércio Ltda., Petrópolis, RJ, Brazil) on each sample, three times, with the active tip placed at the center of the surface. A separate white Teflon matrix was used to standardize color measurement, ensuring consistent positioning and eliminating external light influence. The spectrophotometer measures color gradation based on the CIEL*a*b* color space, allowing three-dimensional color determination as defined by the International Commission on Illumination (CIELab). L* represents lightness (light or dark), a* indicates red (positive a*) or green (negative a*), and b* indicates yellow (positive b*) or blue (negative b*). The color difference between coordinates is calculated by the equation: $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. Brightening is mainly observed as a reduction in yellowness (lower b*) and an increase in whiteness (higher L*). Color variations (ΔE*) are categorized as follows: $\Delta E^* < 1$: color change not detected by the human eye; $\Delta E^* < 3.3$: clinically acceptable color changes; $\Delta E^* > 3.3$: clinically unacceptable color changes, requiring replacement for aesthetic reasons.

After obtaining the initial color and surface roughness data, the specimens were individually immersed for 2 hours per day in flasks containing 5 ml of cola soft drink (Coca-Cola®, pH 2.36; Coca-Cola Co, Ribeirão Preto-SP, Brazil) and kept in a bacteriological incubator at 37°C. After these two hours, the specimens were rinsed, immersed in distilled water, and also kept in the incubator at 37°C. These procedures were performed for 40 days. The flasks were sealed to prevent evaporation and the solution was changed daily. After this process, the test specimens were kept in distilled water for another 24 hours in the incubator for final color evaluation (L*, a*, and b* values for ΔE calculation) and final surface roughness evaluation (Ra).

After obtaining the initial and final data for both surface roughness and staining, the averages were calculated, tabulated, and analyzed using the Kolmogorov-Smirnov and Shapiro-Wilk tests to verify normality of distribution. The data were then subjected to analysis of variance and Tukey's test, with a significance level of 5%. The two-way ANOVA test was used to compare the initial and final conditions of both surface roughness and color change in the different groups.

RESULTS

Regarding surface roughness, no statistical difference was observed between the initial and final conditions. The control groups without treatment (GZ and GX) had worse surface smoothness than any other group.

The hybrid resin groups with finishing/polishing and sealing (GXF and GXV) showed similar surface roughness results regardless of the sealant and had better results than the control groups (GZ and GX) and the GXS group (finishing/polishing only). However, their results were similar to the GZS nanoparticulate resin group (finishing/polishing only) and worse than the GZF and GZV groups (finishing/polishing and sealing), demonstrating that the nanoparticulate composite resin achieved better results with smoother surfaces than the hybrid resin, as shown in Table 3 and Table 4.

Table 3 – Results of the means and standard deviation (SD) of the surface roughness (Ra) of each group of nanoparticulate and hybrid Bulk fill resins.

Nanoparticulate groups	Ra Averages/SD Initial	Ra Averages/DP Final
GZ	0,30±0,02 Aa	0,31±0,01Aa
GZS	0,19±0,01 Bb	0,19±0,02Bb
GZF	0,10±0,01 Cc	0,10±0,01Cc
GZV	0,11±0,02 Cc	0,12±0,02 Cc
Hybrid Groups		
GX	0,39±0,01 Dd	0,40±0,02 Dd
GXS	0,27±0,01 Aa	0,28±0,01 Aa
GXF	0,16±0,02 Bb	0,16±0,01 Bb
GXV	0,20±0,01Bb	0,20±0,02 Bb

*Distinct superscript letters indicate a statistically significant difference ($p < 0.05$). Uppercase letters denote analysis between rows, and lowercase letters denote analysis between columns (Source: Survey Data)

Table 4 - Average initial and final surface roughness (Ra) of the nanoparticulate and bulk-fill hybrid resin groups

Material	n	Ra Averages/SD Initial	Ra Averages/DP Final
Filtek™ Z350XT	40	0,17±0,60 Aa	0,18±0,56 Aa
X-tra fil	40	0,26±0,71 Bb	0,26±0,65 Bb

*Distinct superscript letters indicate a statistically significant difference ($p < 0.05$). Uppercase letters denote analysis between rows, and lowercase letters denote analysis between columns (Source: Survey Data)

Finishing and polishing the composite resin surfaces resulted in lower surface roughness values compared to the control groups, regardless of the resin used. These results demonstrate the importance of performing the finishing and polishing process (Table 5).

Table 5 - Mean (SD) values of initial and final surface roughness (Ra) according to finishing/polishing

Treatments	n	Average Ra/ Initial SD	Ra Averages/ DP Final
No finishing/polishing	20	0,35±0,05 Aa	0,36±0,07 Aa
With finishing/polishing	20	0,23±0,06 Bb	0,23±0,05 Bb

*Distinct superscript letters indicate a statistically significant difference ($p < 0.05$). Uppercase letters denote analysis between rows, and lowercase letters denote analysis between columns (Source: Survey Data)

Treatment with either of the two sealants studied resulted in similar surface roughness values with no statistically significant difference, and their results were better than those of the groups that did not receive this treatment, regardless of the resin used. This suggests that using a surface sealant can be an important step in improving the surface smoothness of composite resin (Table 6).

Table 6 - Mean (SD) values of initial and final surface roughness (Ra) according to sealing

Treatments	n	Average Ra/ Initial SD	Ra Averages/ DP Final
No sealant	40	0,29±0,06 Aa	0,30±0,08 Aa
Fortify	20	0,13±0,07 Bb	0,13±0,08 Bb
VLB	20	0,16±0,08 Bb	0,17±0,07 Bb

*Distinct superscript letters indicate a statistically significant difference ($p < 0.05$). Uppercase letters denote analysis between rows, and lowercase letters denote analysis between columns (Source: Survey Data)

The values for the color change of the two types of composite resins are shown as the average ΔE in Table 7. The control groups (GZ and GX) had clinically unacceptable results (ΔE above 3.3). The other groups (GZS, GZF, GZV, GXS, GXF, and GXV) showed no statistically significant differences with had clinically acceptable color changes ($1 < \Delta E < 3.3$).

Table 7 – Means and standard deviations (SD) of the color change (ΔE00) for each group of nanoparticulate and hybrid bulk fill resins

Nanoparticulate groups	ΔE Averages/SD
GZ	3,49±0,22 A
GZS	2,15±0,18 B
GZF	2,26±0,31 B
GZV	2,30±0,26 B
Hybrid Groups	
GX	3,58±0,41 A
GXS	2,26±0,21 B
GXF	2,35±0,25 B
GXV	2,39±0,22B

*Distinct superscript letters indicate a statistically significant difference ($p < 0.05$). Uppercase letters denote analysis between rows, and lowercase letters denote analysis between columns (Source: Survey Data)

DISCUSSION

Nanoparticulate resins have different mechanical properties than bulk-fill hybrid resins. Several studies have shown that composite resin restorations should have a highly polished surface to improve aesthetics and durability and to hinder biofilm adhesion. The difficulty in achieving this surface is due to the shape of the tips and limited access to certain areas[4,21]. The composition of the composite resin, including the matrix and filler particles, influences the surface smoothness of restorations because smaller fillers provide better results with less surface protrusion.[13,20] Some studies have shown that the smaller and more closely packed the filler particles, the better the surface smoothness, the lower the polymerization shrinkage, and the better the mechanical properties, confirming the contribution of nanotechnology to the development of this material[21]. In the present study, the nanoparticulate composite resin had lower surface roughness values compared to the bulk-fill hybrid resin at both measured time points, regardless of the treatment performed, suggesting that its composition may have contributed to smoother surfaces.

Studies have shown that nanometric composite resins offer advantages such as low polymerization shrinkage, improved surface smoothness, reduced wear, better color stability, and enhanced mechanical properties. The size and geometry of the particles in these resins directly influence surface smoothness and stain resistance. This effect can be attributed to the combination of nanoparticles in clusters (nanoclusters), which reduce the space between particles, increase the percentage of filler, and improve physical properties[6,7,22.] These findings may explain the present study, where lower roughness values were observed in Filtek Z350 XT compared to X-tra fil resin. However, this does not explain the results regarding color change, as the outcomes were similar to those of the X-tra fil resin.

Finishing composite resins aims to improve the adaptation of the restorative material to the tooth by removing excess material and refining the contour of the occlusal surfaces, while polishing aims to achieve better surface smoothness. Both are essential for obtaining restorations with proper shape and smoothness, appropriate anatomy, and good marginal adaptation, which hinder bacterial growth, secondary caries, gingival inflammation, and surface staining[1,8,18,19]. Studies have shown that aluminum oxide discs with decreasing abrasiveness provide favorable results for finishing and polishing[3,10]. The present study supports these findings, as the lowest surface roughness values were found in the finishing/polishing groups, with a statistically significant difference from the control groups that did not receive this treatment, suggesting its importance for achieving better results regardless of the resin used. Within the limits of this study, the results showed that finishing/polishing and surface sealants improved the surface smoothness of both nanoparticulate and hybrid composite resins, corroborating other studies where these treatments also influenced the surface quality of composite resins and their resistance to color alteration[2,25].

The instruments, materials, and procedures used during finishing and polishing can generate microcracks, cause loss of the outermost layer (with a higher degree of conversion), and expose flaws due to the physicochemical stresses of polymerization, among other effects.[12,19] Microcracks or microfissures at the matrix/filler interface facilitate the penetration of dietary and bacterial metabolic liquids, potentially altering the resinous organic matrix and affecting the longevity of the restoration. Several studies have shown that finishing and polishing are essential procedures to complete the restoration with more favorable results. Some of these studies have proposed minimizing or eliminating microcracks by applying a sealant to the composite resin surface. Generally, these sealants are high-flow, low-viscosity resin monomers that act as adhesives, also sealing marginal gaps at the resin/enamel interface[11,14,15]. In the present study, finishing and polishing were performed using aluminum oxide abrasive discs and polishing paste with felt. The results were significant regarding roughness and color change, while the application of sealant can be an important immediate step to improve surface roughness, since there was no statistical difference between the groups regarding color change.

There is debate in several studies regarding the durability of surface sealants, with a consensus that resealing is necessary and should be performed within approximately six months to maintain clinical benefits. This is due to multiple associated factors such as the type of finishing and polishing, the photoactivation method, the composition of the restorative material and the sealant, among others.[16,24,17] Regardless of the use of surface sealant, studies show that preserving any composite resin restoration is important to maintain smooth surfaces, hinder biofilm adhesion, and prevent a decrease in longevity[17,26,27].

Regarding color change, evidence from different studies indicates that finishing and polishing are not the determining factors influencing color change, as other factors related to materials, diet, and hygiene habits may be more relevant and make the restoration more susceptible to color change[23,29,30]. In this study, the groups with the best results for surface roughness (GZF and GZX) did not influence color change, as they were similar to the other groups with clinically acceptable color changes ($1 < \Delta E < 3.3$). Only the control groups (GZ and GX) without finishing and polishing showed clinically unacceptable color changes (ΔE above 3.3), demonstrating the importance of performing finishing and polishing, while the use of surface sealant did not influence the results.

Studies have evaluated color change visually or with specific devices such as spectrophotometers, which eliminate subjective aspects in color comparison[5,9,29]. In the present study, the Filtek™ Z350XT composite resin, after finishing and polishing, presented smoother surfaces compared to the X-tra fil resin. However, regarding color change, the results were similar and clinically acceptable, suggesting that finishing and polishing reduced the possibility of color change as much as the sealant, but were not the determining factor. Thus, intrinsic factors of composite resins or sealants, such as composition, porosity of aggregate filler particles, water sorption, and chemical degradation, as indicated in some studies, may help explain these results[11,24,28].

Coca-Cola did not alter the surface roughness of the composite resins after 40 days; however, it did influence color change in all groups. Only the untreated control groups (GZ and GX) showed clinically unacceptable results (ΔE above 3.3). This finding supports previous studies that evaluated the color stability of composites and reached similar conclusions. Factors such as the pH of the coloring agent, the degree of polymerization conversion of the composite resins, and the types of monomers in the resin and sealant, although not investigated in this study, may contribute to staining susceptibility by affecting the physical properties and clinical performance of composite resins regarding color change[3,4,16,23].

The natural nanotechnology liquid VLB, a single-bottle product specifically for plastic surfaces, performed similarly to the Fortify sealant. Further studies with additional tests should be conducted to verify its performance in other situations. Composite resin restorations are in high demand in dental offices, and various types are introduced to the market every year. Several factors can affect their properties, which must be evaluated to preserve quality and increase longevity. Based on the limitations of this study, further tests are recommended to assess the performance of the VLB sealant in other simulated conditions.

CONCLUSION

The nanoparticulate composite resin had better surface smoothness than the bulk-fill hybrid resin. The sealants showed similar performance in terms of roughness and staining. The finishing/polishing and the sealants helped maintain surface roughness after immersion in refrigerant. Staining occurred in the composite resins in all groups; however, only the control groups (GZ and GX) were not clinically acceptable.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

CORRESPONDING AUTHOR

Victor Eduardo de Souza Batista
R. José Bongiovani, 700 - Cidade Universitária
Postal Code 19050-920
Presidente Prudente - SP, Brazil
E-mail:victor_edsb@hotmail.com

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