Original Article

EFFECT OF SEALANTS IN THE COMPOSITE SURFACE ROUGHNESS AFTER TOOTH BRUSHING

EFEITO DE SELANTES NA RUGOSIDADE DE RESINAS COMPOSTAS APÓS A ESCOVAÇÃO SIMULADA.

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ABSTRACT: This *in vitro* study evaluated the influence of 4 surface sealers on the surface roughness of composite resins. Fifty specimens were divided into 10 groups, as follows: G1. (Control 1) Concept resin; G2. Concept + Fortify; G3. Concept + Biscover; G4. Concept + Lasting Touch; G5. Concept + Fill Glaze; G6. (Control 2) Esthet X; G7. Esthet X + Fortify; G8. Esthet X + Biscover; G9. Esthet X + Lasting Touch; G10. Esthet X + Fill Glaze. Specimens (15mm in length, 4 mm in depth and 5 mm in width) were made using a matrix and were stored in distilled water at 37ºC for 24 hours. After storage, specimens were polished using 320, 600 abrasive SiC paper under running water and the initial roughness was measured using a perfilometer. Surface sealers were applied and a new measurement of roughness was made. Specimens were submitted to 100,000 cycles of abrasive dentifrice brushing followed by another surface roughness measurement. Qualitative analysis was made by using SEM. Results were submitted to 3-way modified ANOVA ($p<0.05$) and Tukey's test. **Results:** Surface sealant provided smoother surfaces for both tested composite resins (G2=0.0727, G3=0.0147, G4=0.0307, G5=0.0253, G7=0.0173, G8=0.0333, G9=0.0480, G10=0,0480). After the abrasion test, the control group presented lower roughness surface (G1=0.0600, G6=0.1007). No statistical difference were found between Fortify (G2=0.0740, G7=0.0673) and Biscover (G7=0.0440). Lasting Touch presented rougher surfaces in relation to the other groups (G4= 0.1253, G9=0.0980), followed by Fill Glaze (G5=0.0933, G10= 0.0847). The application of surface sealant did not provide roughness optimization after tooth brushing simulation for the 2 composite resins tested.

KEYWORDS: Composite resins; sealants; roughness, wear.

INTRODUCTION

The use of composite resins increased considerably in recent years as their mechanical and physical properties were highly improved. (ATTAR, 2007). Nevertheless, the clinical behavior of such material is still limited by its low wear resistance, loss anatomic form and superficial gloss, polymerization shrinkage and marginal microleakage (DICKINSON et al., 1990; DICKINSON; LEINFELDER, 1993; DOS SANTOS et al., 2003; TAKEUCHI et al., 2003; UCTASLI et al., 2007; LOPES et al., 2012).

Also, even after accomplishing appropriate finishing and polishing techniques, the surface exhibits microcracks and microdefects, creating a rough surface (TAKEUCHI et al., 2003; UCTASLI et al., 2007). The surface roughness is a microstructural phenomenon of the material created by physical processes which modifies their surfaces (ERGÜCÜ; TÜRKÜN, 2007). Bollen et al. (1997) assure that if the composite restoration has a surface roughness of 0.2 µm (Ra: Roughness Average - µm) or more, dental plaque accumulation may occur. These microdefects can be of 50 µm in depth (LEINFELDER et al., 1986). Consequently, more plaque retention followed by secondary caries (UCTASLI et al., 2007; ERGÜCÜ; TÜRKÜN, 2007; DOS SANTOS et al., 2007) and staining (DOS SANTOS et al., 2007) may occur and thus affect the restoration gloss and final esthetic (YAP et al., 1997).

Surface sealants has been investigated in an attempt to overcome these problems. The so-called surface penetrating sealant should be able to fill, by capillary action, the structural microdefects and microfissures that are formed during the insertion technique and finishing-polishing procedures, improving the clinical longevity of the restoration (DICKINSON et al., 1990; DICKINSON; LEINFELDER, 1993; ERGÜCÜ; TÜRKÜN, 2007). This approach is assumed to provide a more uniform, regular surface, thereby enhancing surface

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smoothness (TAKEUCHI et al., 2003; BERTRAND et al., 2000).

This study evaluated the effect of surface sealant in the roughness of 2 composite resins, before and after the tooth brushing abrasion test. The null hypothesis was that the application of surface sealants did not affect the composite resin surface roughness.

MATERIAL AND METHODS

Specimen Preparation

Twenty five specimens from each composite resin (Concept, Vigodent; Esthet X, Dentsply) were made at 23 ± 2°C and 50±10% relative humidity using a rectangular metallic matrix (15mm in length, 4 mm in depth and 5 mm in width). The materials and manufacturers instructions used in this study are outlined in Table 1.

Table 1: Material Used

Materials	Composition	Batch #
Concept/Vigodent	BisGMA; UDMA, bariun silicate and aluminun	not informed
Esthet X/Dentsply	Hazardous Components, Titanium Dioxide, Silica Amorphous, Barium boron fluoroalumino silicate glass, Urethane modified Bis-GMA dimethacrylate	893473
Biscover/Bisco	Dipentaerythritol pentaacrylate Ethanol	0700011005
Fortify/Bisco	Urethane Dimethacrylate Ethoxylated Bis-GMA	070011981
Lasting Touch/Dentsply	Nanofillers, acetone, organic solvent, photo initiator, stabilizer, urethane resin, organic acid	070920
Fill Glaze/Vigodent	Metyl metacrilate, photoiniciator, acrylates.	055/08

Increments were light cured for 20 seconds with a halogen light Curing Light 2500 (3M/ESPE, Saint Paul - MN, USA), with 500mW/cm^2. The specimens were stored in water at 37ºC for 24 hours. Afterwards, they were finished with 320 and 600-grit silicon carbide abrasive paper and water (Arotec S/A Ind e Com, Brazil). Then, specimens were ultrasonically cleaned for 10 minutes to remove debris from abrasive paper.

The prepared specimens were randomly divided into 10 groups (n=5), as follows:

G1: Concept, control group
G2: Concept with Fortify
G3: Concept with Biscover
G4: Concept with Lasting Touch
G5: Concept with Fill Glaze
G6: Esthet X, control group
G7: Esthet X with Fortify
G8: Esthet X with Biscover
G9: Esthet X with Lasting touch
G10: Esthet X with Fill Glaze

We studied the roughness of the resin in three different times: before, after sealant application and after brushing abrasion test.

Baseline surface profile measurement

Surface profile/roughness tracings were made on the top surface using Hommel Tester T1000 equipment (Hommelwerke GmbH, Schwenningen, Germany). They were expressed in Ra values. On each evaluated surface, three different traces along its length were performed to assure linear profile pattern. For Ra, tracing parameters were established at Lt (plotting limit): 1.5mm and Lc (filtering - wavelength limit): 0.25mm. Baseline roughness was obtained by the arithmetic means of these three readings (µm).

Surface sealant application

The composite resin surface was etched with a 37% acid phosphoric acid gel, rinsed thoroughly and the excess water removed with a mild oil-free air stream, following the fabricant directions. With a disposable micro brush, a uniform layer of the low-viscosity agent was applied over the etched area, gently air thinned for 15 seconds and light-cured, following the fabricant directions.

Surface sealant profile measurement

The surface roughness after the application of the surface sealant was evaluated as previously described for baseline condition. After that, the specimens were stored in deionized water (37° C) for 7 days.

Brushing abrasion

The entire specimen's surfaces were subjected to a toothbrush abrasion test. The test was performed with a toothbrushing machine with controlled temperature of 37±2°C. A load of 300g with soft nylon bristles (Colgate, Palmolive, Brazil) was applied on the samples. Slurry was prepared by mixing 2:1 of deionized water and Colgate MFP (Colgate-Palmolive Co., Osasco, São Paulo, Brazil) dentifrice by weight, immediately before testing. Slurry was prepared with 50 grams of Colgate MFP (Colgate-Palmolive Co., Osasco, São Paulo, Brazil) toothpaste and 100 grams of distilled water. One hundred thousand brushing strokes were performed for each specimen, and 0.4 mL slurry was ejected each 2 minutes. Following the test, the specimens were removed and ultrasonically cleaned with water for 10 minutes.

Table 2. Inicial, Post-Sealant and Post-Abrasion surface roughness means (µm) and Standard deviation for the tested conditions for Concept

Groups	Inicial	Post-Sealant	Post-Abrasion
G1- C	0.1893±0.0338 **Aa**	0.1893±0.0338 **Aa**	0.0600±0.0118 **Bab**
G2- C+F	0.1447±0.0288 **Aa**	0.0727±0.0169 **Bb**	0.0740±0.0167 **Bbc**
G3- C+B	0.1627±0.0228 **Aa**	0.0147±0.0045 **Bc**	0.0427±0.0076 **Ca**
G4- C+LT	0.1580±0.0177 **Aa**	0.0307±0.0098 **Bc**	0.1253±0.0145 **Cc**
G5- C+FG	0.1993±0.0174 **Aa**	0.0253±0.0107 **Bc**	0.0933±0.0244 **Cd**

C= Concept; B= Biscover; F= Fortify; FG= Fill Glaze e LT= Lasting Touch. Capital letters show difference between the phases. Lowercase letters show difference between groups.

Final Surface Profile Measurement

The same protocols used for baseline surface profile/roughness determinations were repeated.. Final Ra was obtained by the arithmetic mean of three readings performed on each specimen's abraded area. R changes were obtained by the percentage difference between baseline and final means.

Scanning electron microscopy (SEM) examination

Representative samples, before and after toothbrushing abrasion, were selected for qualitative microscopic examination. Each specimen was dried for 24 h at 37 °C, gold sputter-coated and had the top surface analyzed by a scanning electron microscope at 500X magnification (MEV – JEOL JLM 5600 LV).

Statistical analysis

Data were analyzed using 3-way ANOVA mist method, and pair wise comparisons were performed using the Tukey's test (α=0.05).

RESULTS

The analysis of data revealed a statistically significant difference ($p<0.05$) between measurements performed before and after the abrasion test and applications of surface sealant. Means and standard deviations are shown in Tables 2 and 3.

Table 3. Inicial, Post-Sealant and Post-Abrasion surface roughness means (µm) and Standard deviation for the tested conditions for Esthet X

Groups	Inicial Ra	Post-Sealant	Post-Abrasion
G6- E	0.1947±0.0607 **Aa**	0.1947±0.0607 **Aa**	0.1007±0.148 **Ba**
G7- E+F	0.1567±0.0349 **Aa**	0.0960±0.0095 **Bb**	0.0673±0.0215 **Bbc**
G8- E+B	0.1820±0.0330 **Aa**	0.0173±0.0130 **Bc**	0.0440±0.0224 **Bc**
G9- E+LT	0.1760±0.0344 **Aa**	0.0333±0.0085 **Bc**	0.0980±0.0152 **Cab**
G10- E+FG	0.1540±0.0219 **Aa**	0.0480±0.0201 **Bbc**	0.0847±0.0090 **Cab**

B= Biscover; E= Esthet-X; F= Fortify; FG= Fill Glaze e LT= Lasting Touch. Capital letters show difference between the phases. Lowercase letters show difference between groups.

Surface sealant application provided smoother surfaces for of composite resins tested (G2=0.0727, G3=0.0147, G4=0.0307, G5=0.0253, G6=0.0960, G7=0.0173, G8=0.0333, G9=0.0480). After the abrasion test, the control group presented lower roughness surface (G1=0.0600, G6=0.1007). Fortify (G2=0.0740, G7=0.0673) and Biscover (G7=0.0440) did not have difference statistically. For Biscover, the lowest values were found (C+B=0.0427 µm, E+B= 0.0440 µm). Lasting Touch presented rougher surfaces (G4= 0.1253, G9=0.0980), followed by Fill Glaze (G5=0.0933, G10= 0.0847).

An examination of the SEM micrographs taken of all groups tested revealed a concordance with the numeric results. Figure 1 shows composite resin Concept (A) and Esthet X (C) before and after (B and D) toothbrushing abrasion test (SEM 500X); Figure 2 shows surface sealant Fortify (A) and Biscover (C) before and after (B and D) toothbrushing abrasion test; Figure 3 represents surface sealant Lasting Touch (A) and Fill Glaze (C) before and after (B and D) toothbrushing abrasion test.

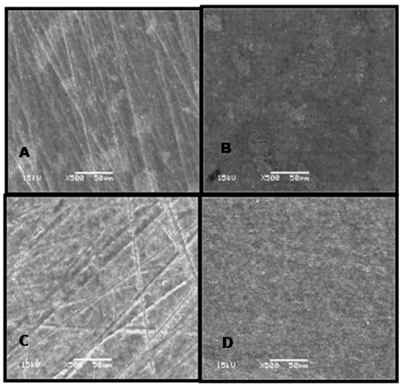

Figure 1. Composite resin before (A- Concept; C- Esthet X) and after (B- Concept; D - Esthet X) toothbrushing abrasion test (SEM 500X).

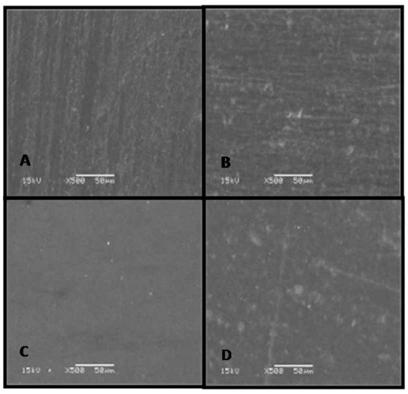

Figure 2. Surface sealant before (A- Fortify; C- Biscover) and after (B - Fortify; D –Biscover) toothbrushing abrasion test).

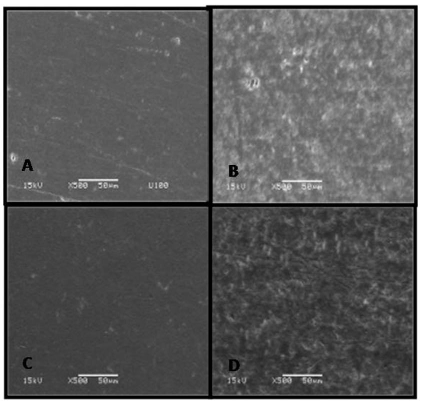

Figure 3. Surface sealant before (A- lasting Touch; C- Fill Glaze) and after (B – lasting Touch; D – Fill Glaze) toothbrushing abrasion test).

DISCUSSION

The present findings revealed that application of surface sealant can promote smoother surfaces for all groups tested, before the toothbrushing abrasion test. These results are similar to those reported by Dos Santos et al. (2007) who noticed that, after brushing test, the application of surface sealant (Protect-it!) decreases the surface roughness of restorations.

A non-smooth surface can cause loss of surface gloss and alter the esthetics of a composite resin restoration (KORKMAX et al., 2008), facilitating the mechanical retention of bacteria. Surface roughness is a micro structural phenomenon of materials created by a series of physical processes that alter their surface. These characteristics has been well determined by other authors (TAKEUCHI et al., 2003; D'ALPINO et al., 2006; KORKMAX et al., 2008; YAP et al., 2005; KAWAI; LEINFELDER, 1993) by the use of perfilometers of mechanical contact, that detect irregularities using a small needle that slides through the surface. Ideally, surface roughness might be equal or smaller than the one of enamel in contact to enamel in oclusal contact areas (Ra=0.64 μm). On the other hand, Bollen et al. (1997) affirmed that a surface roughness higher than 0.2 μm (Ra) or more would result in accumulation of bacterial plaque, generating periodontal pathologies and carious lesions (DOS SANTOS et al., 2003; TAKEUCHI et al., 2003; BOLLEN et al., 1997; VAN DIJKEN; RUYTER, 1987). Results showed in Tables 2 and 3 demonstrates that surface roughness values on the initial phase, after sealant application and after abrasion process were less than 0.2μm.

To fulfill its performance, surface sealants might have good wettability, low contact angle with the restoration surface, low viscosity and good capacity of penetrating the existing micro defects (D'ALPINO et al., 2006; CHIMELLO et al., 2001). For this reason, the presence of components such as low molecular weight monomers has been described as essential (D'ALPINO et al., 2006). Dickinson et al. (1990) assumed that a surface sealant, consisting of BisGMA modified by low molecular weight monomers such as TEGDMA and THFMA, could control the characteristics of viscosity and wettability.

The measurements for Fortify (C+F= 0.0740 μm, E+F= 0.0673 μm) and Biscover (E+B= 0.0440 μm) did not demonstrate a statistically significant difference ($p>0.05$).

The wear resistance of composite resins can be enhanced by the use of surface sealants, as long as it is annually applied (DICKINSON et al., 1990; DICKINSON; LEINFELDER, 1993). In an *in vivo* study of Dickinson et al. (1990; 1993) they found, after one year, wear values of sealed restorations equivalent to half of those found in non-sealed restorations. Besides that, these low viscosity resins can promote a better wear resistance on the tooth-restoration interface of indirect luting restorations (PRAKKI et al., 2005).

Results of this study show inferior roughness values before and after brushing for Biscover, when applied on the surface of the two composite resins tested, as observed in Tables 2 and 3. Davidi et al. (2007, 2008) assures that the application of a surface sealant and bonding agent on the surface of provisional indirect restorations can be effective on the prevention of bacterial biofilm analyzed after 12 hours. For them, Biscover is capable of preventing the bacterial biofilm by inhibiting the bacteria adsorption to the surface.

After the abrasion process, higher roughness values were presented by Lasting Touch sealant, followed by Fill Glaze on the two composites resins tested. Bertrand et al. (2000) related that the thickness of the non-filled sealant Fortify layer presented considerable variation (0-70μm), when analyzed under scanning electron microscopy (SEM) and it was practically impossible to obtain a uniform macroscopic layer. Thus, for the Lasting Touch that has nanoparticles as fillers, the formation of a uniform layer would be critical, due to the great viscosity and low flow of this material when compared to the non-filled sealant.

Characteristics such as size of fillers of dentifrice employed, hardness, and number of bristles on the toothbrush must be considered, once they can affect the brushing process and the alteration caused on the specimen (HARTE; MANLY, 1975; DE BOER, et al., 1985). The number of cycles that simulates 1 year of brushing on the oral cavity can vary from 4,320 (VAN DIJKEN; RUYTER, 1987) to 16,000 (AKER, 1982). According to Goldstein et al. (1991), 100,000 simulated brushing cycles are equivalent to 10 years of brushing under clinical conditions. Aker (1982) relates that the number of cycles that vary from 4,320 to 16,000 correspond to one year of brushing. Heath, Wilson (1974) reported that a patient realizes, approximately, 4.5 brushing cycles per second. Buchalla et al. (2000), from this number of cycles, says that 6.000 simulated brushing cycles correspond, approximately, 1 to 2 months of brushing *in vivo*. The author's assumption is that a person brushes, on average, 20 second for each sextant, totalizing 90 cycles (20 seconds times 4.5

cycles). Based on this principle, this study realized the equivalent to 29 months of brushing *in vivo*, approximately.

The surface sealants were shown to penetrate the microfissures filling the irregularities of the underlying composite, decreasing the surface roughness before the toothbrushing abrasion. However, no improvements were founded after the abrasion test, assuring the annual reapplication as being necessary. Despite that, to assure that the surface roughness is preserved and clinical longevity of the restoration may be increased, further studies should be done.

One limitation of the in vitro studies is the no reproduction of oral environment, such as saliva, oral mastication and antagonist occlusion, and other factors that can affect the roughness surface of the dental materials. Nevertheless, in vitro studies can provide isolated data of some variables with no interference from other factors. Further in vitro and in vivo studies are required to improve the knowledge of the mechanical behavior of the composite resins with surface sealant application and determine their long-term outcome in restorative treatments.

CONCLUSION

The application of surface sealant did not provided optimization superficial integrity after toothbrushing abrasion test for the two composite resins tested.

RESUMO: Este estudo avaliou, *in vitro*, a influência de 4 selantes de superfície na rugosidade de duas resinas compostas. Cinqüenta espécimes foram confeccionados e divididos em 10 grupos com 5 espécimes cada, em função da combinação entre resina composta e selante de superfície, sendo: G1. Controle Concept; G2. Concept + Fortify; G3. Concept + Biscover; G4. Concept + Lasting Touch; G5. Concept + Fill Glaze; G6. Controle Esthet X; G7. Esthet X + Fortify; G8. Esthet X + Biscover; G9. Esthet X + Lasting Touch; G10. Esthet X + Fill Glaze. Os espécimes (15mm X 4 mm X 5 mm) foram confeccionados e armazenados em água destilada à 37ºC por 24 horas. Após este período, os espécimes foram planificados com lixas de granulometria 320, 600 e a rugosidade inicial foi aferida. Aplicaram-se os selantes de superfície e uma nova aferição da rugosidade superficial foi realizada. Os espécimes foram submetidos a 100.000 ciclos de escovação, seguido de nova mensuração da rugosidade. Os resultados foram submetidos aos testes ANOVA a 3 critérios e Tukey. A aplicação do selante de superfície diminuiu a rugosidade superficial das resinas compostas testadas (G2=0,0727, G3=0,0147, G4=0,0307, G5=0,0253, G6=0,0960, G7=0,0173, G8=0,0333, G9=0,0480). Nenhuma diferença estatística foi encontrada entre o grupo Fortify (G2=0,0740, G7=0,0673) e Biscover (G7=0,0440). Os maiores valores de rugosidade foram apresentados pelo grupo Lasting Touch (G4= 0,1253, G9=0,0980), seguido do Fill Glaze (G5=0,0933, G10= 0,0847). A aplicação do selante de superfície não otimizou a rugosidade das duas resinas compostas testadas após o teste de abrasão simulada.

PALAVRAS-CHAVE: Resinas compostas. Selantes. Rugosidade. Resgaste.

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