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Effect of beverages on surface properties of resin-based sealants

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Aim: The aim of this study was to determine degree of conversion of resin-based sealants and the effect of beverages on surface roughness and color change of materials. **Methods:** Two commercial resin-based sealants were evaluated (Defense Chroma® and BioSeal®). Degree of conversion (DC) was initially measured using Fourier-transformed infrared (FTIR). Specimens of each sealant were maintained in distilled water and immersed one hour daily in grape juice and cola drink for 30 days. One group was maintained only in distilled water, as a control. Surface roughness and color change were measured before immersion, after seven days of immersion and after 30 days of immersion. Results were analyzed using t-test, paired t-test, one-way repeated measures ANOVA, one-way ANOVA and post-hoc tests (0.05 level of significance). **Results:** There was no significant difference regarding degree of conversion and initial surface roughness comparing both commercial sealants. Surface roughness increased for BioSeal® immersed in cola drink for 30 days. After 30 days, all groups presented significant color change. **Conclusions:** The effect of beverages on color stability and surface roughness of resin-based sealants depended on exposure time and kind of beverage.

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Introduction

The majority of caries occurs in fissures and pits of molars of children and adolescents[1,2]. Although glass ionomer cements are known by their fluoride release property, resin-based sealants are also commonly used to protect fissures and pits due to its higher retention rate[3]. Its fluoride release through a slow diffusive of filler particles contributes to caries inhibition[4].

Resin materials are submitted to physical stresses and chemical process. One of these factors is the exogenous substances taken in the diet, which contain a variety of acids such as tartaric acid present in grape juice and phosphoric acid in cola beverages[5]. Chemistry and duration of exposure are important to determine the interaction between molecule and material polymeric network[6].

Chemical degradation of materials also depends on composition of material. Resin-based materials are susceptible to degradation, mainly those with no or low inorganic filler content[7,8], such as sealants. The early effect of degradation is an increased surface roughness, which leads to raise biofilm accumulation and color change due stain penetration into the polymeric matrix[8].

Sealants have been the subject of numerous studies evaluating effectiveness, adaptation and penetration into fissures and fluoride release[4,9]. In the oral environment, dental material is also subjected to chemical and physical insults. Hence, the purpose of this study was to determine degree of conversion of resin-based sealants and the effect of beverages on surface roughness and color change of materials.

Methods

Two resin-based sealants were evaluated: Defense Chroma® (Angelus, Londrina, Brazil) and BioSeal® (Biodinâmica, Ibiporã, Brazil), whose composition is in Table 1.

Degree of conversion (DC)

The DC was evaluated by FTIR spectrometer. A drop (5 µL) of each sealant (n=3) was photoactivated for 20 s by a light-emitting diode (LED) with irradiance value of 1200 mW/cm^2 (Radii cal, SDI, Bayswater, Australia). Absorbance spectra were obtained before and immediately after light polymerization. The DC was calculated considering the intensity (peak height) of aliphatic carbon-carbon double bond stretching vibration at 1635 cm^{-1} and the symmetric ring stretching at 1610 cm^{-1} from the polymerized and unpolymerized samples.

Table 1. Composition of resin-based sealants used in the present study.

Sealant	Manufacturer	Composition	Lot	Photoactivation time
BioSeal®	Biodinâmica, Ibiporã, Brazil	TEGDMA, Bis-GMA, BHT, silicon dioxide, sodium fluoride, calcium fluoride and catalyst	27025	20 s
Defense Chroma®	Angelus, Londrina, Brazil	Bis-GMA, modified urethane, TEGDMA, barium aluminum borosilicate, tetra-acrylic ester, phosphoric acid, sodium fluoride, N-methyl diethanolamine and camphorquinone	20412	20 s

Immersion of specimens in beverages

Fifteen disc-shaped specimens (10 mm x 2 mm) were prepared for each resin-based sealant. Materials was photoactivated for 20 s, according to the manufacturer's recommendations. After 24 h, the specimens were polished using a manual polisher (Aropol 2v, Arotec, Cotia, Brazil) through a series of silicon carbide (SiC) papers (400-, 600-, 800- and 1200-grit) for 2 minutes each and with a felt disc saturated with an alumina suspension. To evaluate surface roughness and color stability of materials in beverages, specimens of each sealant were randomly distributed in three subgroups (n=5) of beverages (distilled water, DellValle® grape juice, and Coke® cola drink).

Beverages were maintained at 4 °C during the period of study (30 days) and at room temperature before placing specimens for acid challenge. Each specimen was individually immersed in a vial containing 5 mL of beverage for one hour daily at room temperature. Specimens were washed with distilled water and stored again in distilled water at 37 °C. As a control group, specimens were individually immersed in vials containing distilled water for 24 h per day, spending one hour at room temperature. Vials were sealed during immersion to prevent the evaporation of beverages. All solutions were renewed daily.

pH measurement

Determination of beverages' pH was performed at room temperature (22 ± 2 °C) using a pH meter (DM-22, Digimed, Campo Grande, Brazil). Results of pH were obtained from an average of three measurements. It was measured before using beverages.

Surface roughness

Surface roughness (Ra) was measured using a roughness tester (SJ-201, Mitotoyo, Kawasaki, Japan) on surface discs of resin-based sealants. Results were obtained by averaging three equidistant lines of 2 mm. Surface roughness was measured at baseline, after seven days of immersion and after 30 days of immersion of specimens.

Color change

Color measurements of specimens were performed according to the CIE L*a*b* color scale, relative to standard illuminant D65, over a black and white backgrounds by a reflection spectrophotometer (CM-2500d, Konika-Minolka, Tokyo, Japan), with inclusion of ultraviolet (UV) component and exclusion of specular component (SCE) geometry. The aperture size was 3 mm, illuminating and viewing configurations were CIE diffuse/10° geometry. Before measurement, the spectrophotometer was calibrated using the supplied white calibration standard. The reflectance spectra were obtained from 400 to 700 nm. Due to the use of black and white backgrounds, Kubelka-Munk's theory was used to calculate reflectance spectra of infinite thickness. Chromaticity coordinates (X, Y, Z) of CIE (The Comission Internationale de L'eclairage) were calculated using reflectance spectra of infinite thickness. The coordinates were converted to CIE L*a*b* parameters. The color measurements were performed at baseline, after seven days of immersion and after 30 days of immersion. Color change (ΔE) was calculated from differences between L*a*b* parameters between baseline and different times.

Statistical analysis

Statistical analysis was performed using Sigma Plot 11.0. The results were initially analyzed using the Kolmogorov–Smirnov test. T-test was used to analyze initial surface roughness and DC, comparing both sealants. One-way repeated measures ANOVA was performed to compare roughness among different times. Paired t-test was used to compare color change among times. In addition, one-way ANOVA and Tukey post-hoc tests were performed to analyze color changes among groups of different sealants and immersion beverages. The statistically significant level was 0.05.

Results

Degree of conversion for Defense Chroma® was 49.23 ± 2.46% and for BioSeal® was 52.28 ± 2.86%, presenting no statistically significant difference between sealants.

Values of pH for distilled water, grape juice and cola drink were 5.53, 3.09 and 2.72, respectively.

Results of surface roughness are presented in Table 2. There is no difference in initial surface roughness comparing sealants, presenting a roughness of 0.17 (±0.05) for Defense Chroma® and 0.18 (±0.09) for BioSeal®. Surface roughness did not alter, except for BioSeal® immersed in cola drink for 30 days ($P < 0.05$).

Table 2. Mean and standard deviation of surface roughness (μm) and color change (ΔE) for BioSeal® and Defense Chroma® sealants immersed in distilled water, grape juice and Coca-Cola® for 7 and 30 days.

Initial			**Surface roughness**		**Color change (ΔE)**	
		7 days	**30 days**	**7 days**	**30 days**	
BioSeal®	Distilled water	0.11 (± 0.03)^{a}	0.17 (± 0.04)^{a}	0.15 (± 0.06)^{a}	1.92 (± 0.49)^{Aa}	15.38 (± 0.64)^{ABb}
	Grape juice	0.24 (± 0.18)^{a}	0.24 (± 0.11)^{a}	0.24 (± 0.12)^{a}	1.28 (± 0.91)^{Aa}	15.32 (± 0.41)^{ABb}
	Cola	0.20 (± 0.06)^{a}	0.26 (± 0.06)^{a}	0.49 (± 0.13)^{b}	1.33 (± 0.41)^{Aa}	15.89 (± 0.69)^{Ab}
Defense Chroma®	Distilled water	0.15 (± 0.05)^{a}	0.17 (± 0.06)^{a}	0.16 (± 0.06)^{a}	5.11 (± 2.44)^{Ba}	13.70 (± 0.77)^{Bb}
	Grape juice	0.19 (± 0.06)^{a}	0.20 (± 0.12)^{a}	0.21 (± 0.07)^{a}	4.53 (± 0.48)^{Ba}	14.27 (± 1.02)^{ABb}
	Cola	0.19 (± 0.08)^{a}	0.24 (± 0.14)^{a}	0.25 (± 0.06)^{a}	5.34 (± 1.47)^{Ba}	14.31 (± 1.33)^{ABb}

Values followed by identical lower case letters denote no significant difference ($P > 0.05$) in the same row. Values followed by identical capital letters denote no significant difference ($P > 0.05$) in the same column.

Defense Chroma® presented higher ΔE than BioSeal® after seven days of immersion ($P < 0.05$) independently of beverage (Table 2). After immersion for 30 days, all groups presented higher ΔE than after seven days ($P < 0.05$). Although color change occurred for all specimens, higher difference was between BioSeal® immersed in Cola drink and Defense Chroma® in distilled water.

Discussion

Sealants protect high-risk children and adolescents from caries[2,10]. Low amount or no fillers of these resin-based materials, which promote enough flow to allow adequate penetration of material into pits and fissures influence properties of material[3,11]. In the present study, sealants presented similar degree of conversion and susceptibility to chemical degradation in challenge conditions, except for BioSeal® immersed in cola drink after 30 days.

Regarding performance of application of sealants, previous studies extensively discussed about retention, which is higher for resin-based materials than for glass ionomer cements[12]. In addition, the use (or not) of adhesive systems with sealants was also explored[3]. Here is the first step toward the goal of elucidating surface properties of resin-based sealants in challenge conditions.

High degree of conversion represents low amounts of released unreacted monomers and high resistance to degradation[6]. Degree of conversion of BioSeal® presented no significant difference compared to Defense Chroma®. Their results are comparable to other experimental and commercial adhesives[13], sealants[14] and composite resins[15]. Although sealants had different filler particles, they showed no difference in polymerization behavior, such as previously results, also evaluating other resin-based materials[16].

Color stability and surface roughness are mostly tested for composite resin by immersion into red wine, tea and coffee[10,17]. There is a lack of studies related to pediatric situations, when sealants are often used as a preventive method for caries. Sealants are used for children and adolescents at high risk for caries, who generally consume sugary beverages[10]. Most of these have strong pigments and erosive potential due to their acidity. In the present study, simulating high daily frequency, it was possible to notice color change in the medium term and increased roughness for BioSeal® immersed in cola drink for 30 days. Increased time of exposure to beverages results in higher color change and roughness alteration because it allows more chemical interaction between beverage and organic matrix. Besides hydrolytic degradation, the interaction with organic acids of beverages induces faster leaching of monomers by catalysis of ester groups from monomers[18]. Phosphoric acid, presented in cola drinks, results more erosive effect in present sealants and also in tooth tissue[19].

Degradation effects on polymeric matrix are initially perceived by increased surface roughness[8,20], which facilitates the retention of bacterial plaque and extrinsic stains[8,21]. BioSeal® presented increased roughness, due to higher hydrophilic monomers and different filler particles that lead to chemical degradation[8,22,14].

Extrinsic compounds interact with the polymeric network in free volume spaces between polymer chains, resulting in colored oxidation products[8,23,24]. Urethane methacrylate, due to its low water sorption and solubility[6], presents more resistance to staining than hydroxyl groups[25]. Defense Chroma® contains urethane groups in its composition, which explains its resistance to discoloration. Defense Chroma® and Bioseal® presented higher color change than acceptable difference ($\Delta E > 3.3$)[26] in 30 days, even immersed in water.

Measurement of color parameters is based on reflectance spectra. Evaluating a non-opaque material, there is a tendency to result in a gray effect, as occurs using a black background[24] and in class III and IV restorations[27]. In this study, black and white backgrounds were used to avoid a gray effect in non-opaque sealant evaluation. In this study, Kubelka-Munk was required to simulate an infinite thickness to calculate color parameters. The reflectance at infinite thickness is also known as reflectivity and describes an inherent reflectance and color of material[28].

Although consumption was simulated in the present study, there are also the dilution effects of saliva and other fluids, intermittent exposure to beverages and effect of brushing, which could change exposure time necessary to alter surface properties.

Conclusions

Sealants present discoloration after 30 days. BioSeal® presented increased surface roughness after 30 days of immersion into cola drink. The effect of a beverage on surface properties of resin-based sealants depended on exposure time and kind of beverage.

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