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Effect of the composite surface sealant application moment on marginal sealing of compactable composite resin restoration

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Abstract An analysis was carried out to observe whether the application or not of a composite surface sealant (CSS), as well the moment for CSS application were able to reduce marginal microleakage in compactable composite resin restoration. All the preparations were restored with a compactable composite resin. The restored teeth were randomly assessed. G1 (control group): finished and polished; G2: finished, polished, etched and cover with CSS; G3: immediately after the restoration done the CSS was applied, then finished and polished; G4: CSS applied immediately after the restoration was done, the finished and polished, etched, and covered with CSS. The specimens were isolated with nail polish, thermocycled, immersed in aqueous solution of silver nitrate, and followed in a photo developing solution. The microleakage scores obtained from the occlusal and cervical walls were analyzed with the Kruskall–Wallis nonparametric test. No microleakage was found at the enamel margins. Comparing the microleakage scores at dentin/cementum margins ($p < 0.05$) it was found that G3 ($p = 0.0162$) and G4 ($p = 0.0187$) were able to reduce microleakage when compared with group G2. However the results were not statistically different from the control group. The application of CSS was not able to completely eliminate marginal microleakage at the dentin/cementum margins.

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Introduction

The idea of compactable composite resins was introduced in dentistry to improve the handling characteristics of composite resin [1, 2]. Some modifications of the fillers and the arrangement of the composite resin were made to achieve a high viscosity composite making it more suitable for restoration of posterior teeth [3]. However, it was shown that compactable composites' behavior were similar to those of the conventional small-particle hybrid resin-based composite [4]. Clinical research demonstrated that after 2 years placement of a compactable composite resin restoration, there was an increase of superficial and marginal staining [5].

To reduce the potential of staining [6], composite wear [7] and even eliminating finishing and polishing procedures [8] the composite surface sealant (CSS) application was recommended. CSS could fill gaps or microdefects on the restoration [9] reducing the potential of microleakage [10]. Therefore it was demonstrated that the moment for the application of the CSS had an influence on microleakage [10, 11].

The aim of this article was to compare whether the moment of application of a CSS influenced the marginal microleakage in compactable composite resin restorations. The null hypothesis tested was two-fold: (1) whether the application of CSS resulted in similar microleakage compared to restorations where CCS was not applied; and (2) whether the moment of CCS application influenced marginal microleakage of compactable composite resin restorations.

Materials and methods

Thirty extracted sound human molars were selected for the present study after being examined under a stereoscope microscope at 10× magnification to detect enamel cracks or fissures which could possibly cause errors during the microleakage test. After that the selected teeth were stored in 0.5% chloramine at 4 °C. Sixty standardized class II preparations was made on mesial and distal surfaces of each tooth. A #245 carbide bur (KG Sorensen, Barueri, SP 06454-920 Brazil) under copious water-cooled high-speed handpiece were used in a special device to standardize the dimensions of the cavity preparation [12]. After five preparations the used bur was discarded and a new one was selected. The final preparations showed the following dimensions: 2.0 mm occlusal extension, 3.0 mm buccal–lingual extension and 5.0 mm occluso–cervical extension. The cervical wall was located at the cementum–enamel junction (CEJ). The preparations were then re-evaluated under 10× magnifications to ensure the nonexistence of enamel cracks at the cavosurface margin and that the pulp was exposed. If defects were detected the tooth was discarded.

Each prepared tooth was placed in a 0.75-inch-diameter polyvinyl chloride ring filled with auto-cured acrylic resin to enable root sealing. A metallic individual matrix (GoMat/GoCap, Ivoclar Vivadent, Schaan 9494, Liechtenstein) was placed and adapted to the cavo-surface margins with green modeling impression compound (Kerr Impression Compound, Kerr, Orange, CA 92867) to allow the proximal wall reconstruction and reduce the chance of composite overhangs. The materials used to restore the preparations as well the restorative technique were standardized for all groups (Table 1). The materials were applied according to the manufacturer's instructions. Nevertheless the moment for the application of the CSS was modified for the experimental groups.

The preparations were etched with 37% phosphoric acid gel for 15 s, thoroughly rinsed and blot-dried, leaving the dentin moist. The acetone-based dentin adhesive (Bond-1 Primer/Adhesive, Pentron Clinical Technologies, Wallingford, CT 06492) was dispensed into a mixing well and two consecutive coats were applied within 10 s with a fully saturated disposable brush. The tooth surfaces were carefully air-dried for 10 s to remove excess solvent until a shiny surface appeared. Then the preparation was light-cured for 10 s (XL2500, 3M ESPE, St. Paul, MN 55144).

A 0.5 mm thick flowable composite liner (Flow-It, Pentron Clinical Technologies) was applied over the bonded dentin to ensure a better wetting surface for the composite and light cured for 40 s. A compactable composite resin (ALERT™ Condensable Composite, Pentron Clinical Technologies) was inserted into the preparation with an anti-adherent composite resin plugger (SP1, Cosmedent, Chicago, IL 60611) in three horizontal increments from cervical to occlusal. Each increment was light-cured for 40 s. The matrix was then removed and the specimens randomly assigned in four experimental groups ($n = 15$) according to the different surface treatments described in Table 2.

The control group (G1) was stored in distilled water at 37 °C for 7 days. Subsequently, the composite restoration was finished and polished with aluminum oxide disks (Sof-Lex, 3M ESPE) in the sequence described by the manufacturer. After five specimens were polished, new discs were used.

For the group G2 the finishing and polishing were similar to the control group. Immediately after polishing, the composite surfaces and 2.0 mm beyond the cavosurface margins were etched with 37% phosphoric acid gel for 20 s, rinsed and dried. A layer of a CSS (Protect-It, Pentron Clinical Technologies) was applied with a disposable brush to cover the entire restoration surface and marginal area.

Table 1 Materials used for restorations

Material	Product	Composition	Manufacturer	Batch number
Dentin bonding adhesive system	Bond 1	Acetone, Bis-GMA, HEMA, PMGDM	Pentron Clinical Technologies, Wallingford, CT 06492	20450
Low viscosity composite resin	Flow-It	Barium-boro-fluoro silicate glass		26652
Compactable composite resin	ALERT	Dimethacrylate polycarbonate, Silex, magnesium oxide, aluminum oxide, dimethacrylate diphenol-A		28358
Surface sealant	Protect-It	Bis-GMA, UDMA, TEGDMA, THFMA, acrylic esters		26299

Table 2 Experimental groups

Groups	Restorative sequence						
G1	Restoration	→	Polishing				
G2	Restoration	→	Polishing	→	CSS		
G3	Restoration	→	CSS	→	Polishing		
G4	Restoration	→	CSS	→	Polishing	→	CSS

Then the CSS was gently air thinned and light-cured for 20 s.

For group G3, immediately after removing of the metallic matrix and without etching, the CCS was applied with a disposable brush covering the entire composite surface as well as the marginal area and light-cured for 20 s. After that the specimens were stored in distilled water at 37 °C for 7 days and then polished as described for the group G1. Group G4, was carried out as described for group G3, however after being stored in distilled water at 37 °C for 7 days, the specimens were polished and covered with a CCS as described for the group G2.

Thus, to evaluate the microleakage the teeth surfaces were isolated with two layers of fingernail varnish except for 2.0 mm around the restoration. The specimens were then thermocycled for 1,000 cycles at 5 ± 1 °C and 55 ± 1 °C with 30 s of dwell time and immediately immersed in 50% silver nitrate solution for 24 h, followed by 8 h in a photodeveloping solution. The nail varnish was removed, and the specimens were sectioned through the center of the restoration with a precision water-cooled slow speed diamond saw (Isomet 1000, Buehler, Lake Bluff, IL 60044).

The sections were polished with silicon carbide papers (600-, 800- and 1200-grit) in a water-cooled polishing device. Subsequently the restorations were analyzed with a stereomicroscope at 30× magnification and scored for the degree of dye penetration along the occlusal and cervical walls (0–3) by two calibrated independent examiners [12] (Table 3). The obtained data were submitted to Kruskall–Wallis non-parametric test statistical analysis ($p < 0.05$).

Results

There was no dye penetration in the occlusal margins for all experimental groups. At the cervical margins none of the studied groups were capable to completely eliminating marginal microleakage. At the 5% level of significance there was a statistical significant difference between the groups G2 and G3 ($p = 0.0162$) and between the groups G2 and G4 ($p = 0.0187$) (Table 4). Groups G3 and G4 produced statistical similar scores of microleakage (Table 4). Group G2 presented the most microleakage when compared to the other experimental groups (Fig. 1). Nonetheless none of the studied groups were different from the control group.

Discussion

Microleakage is a cause of concern for use of posterior direct composite resin restoration [13]. Microleakage can be defined as penetration of bacteria, fluids, molecules or ions between the cavities walls and the restorative material [14, 15]. One of the primary explanations for microleakage in adhesive restorations is gap formation at the tooth/restorative material interface [15]. One of the causes of gap formation occurs when polymerization stress surpasses the bond strengths of dentin adhesive [16]. Developing techniques which reduce microleakage have been tried [17–19], however, it is still virtually impossible to eliminate microleakage at dentin/cementum margins [12].

Composite surface sealant could theoretically improve the marginal integrity of a composite resin restoration [11, 20–23]. Judes et al. [20] demonstrated that the application

Table 3 Microleakage scores for enamel and dentin/cementum margins

Microleakage scores	Enamel	Dentin/cementum
0	No dye penetration	No dye penetration
1	Dye penetration into enamel	Dye penetration into half extension of the cervical wall
2	Dye penetration beyond the dentin–enamel junction	Dye penetration into complete extension of the cervical wall
3	Dye penetration towards the pulp	Dye penetration into the cervical and axial walls towards the pulp

Table 4 Kruskall–Wallis test for the evaluation of the application of the sealant effect

Kruskall–Wallis	H = 8,16	*p*-value
Group	Ranking	0.04288*
G1	32.8	
G2	39.8	
G3	24.5	
G4	24.8	
Comparison	Difference	*p*-value
G1 and G2	7.0	0.2723
G1 and G3	8.3	0.1913
G1 and G4	8.0	0.2097
G2 and G3	15.3	0.0162*
G2 and G4	15.0	0.0187*
G3 and G4	0.3	0.9583

*Significant at $p < 0.05$

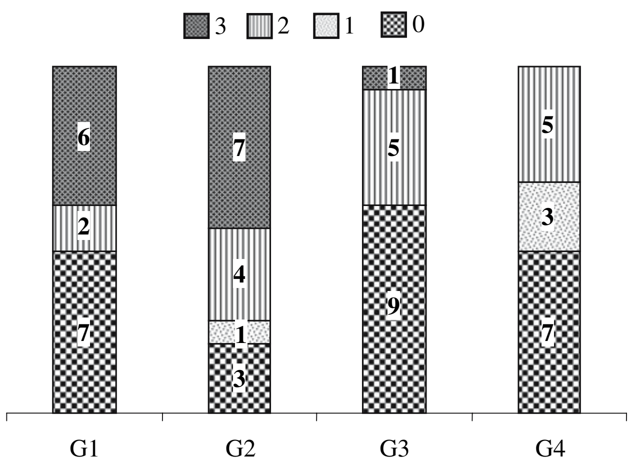

Fig. 1 Frequency of the microleakage scores in experimental group

of a low viscosity resin over the margins of a restoration might penetrate deeply into microgaps as well into surface micro-defects. Nevertheless to be effective the CSS must present good wetting properties [24], low contact angle [25], and the capacity to flow into small defects of the restoration [11]. For this reason the presence of low molecular weight monomers, such as TEGDMA and THFMA, in the composition of a CSS is essential for better infiltration into the small microgaps [24].

Conversely, finishing and polishing procedures might generate heat [26] and reduce restoration resistance for microleakage [19]. Hence microcracks or voids in a composite subsurface layer may become evident [27]. CSS application might be indicated to seal these microstructural defects and reduce the wear of the composite [9]. However, in the present investigation the application of CSS after finishing and polishing did not represent an improvement of the marginal seal. Instead an increase of microleakage compared with the control group was observed. The exposed microdefects and gap of the subsurface layer might be filled with composite resin smear during finishing procedures. Etching may partially remove the composite resin smear, with some particles being trapped in the bottom of the defects. As a result, the CSS may show a superficial seal, with CSS on the top and smear in the bottom. Because of the thermal differences among the restorative materials and tooth, the CSS debonded from the restoration interface allowing microleakage [19, 28].

Composite surface sealant application prior to polishing and finishing procedures was also tested. Immediate CSS application was able to penetrate into composite microdefects and interfacial microgaps prior to their contamination with fluids, saliva, or composite resin smear. Munro et al. [29] showed that etching prior to the application of a CSS did not prevent marginal microleakage. In addition it was shown that marginal integrity is only improved if the composite resin fillers' size were up to 1 µm [7]. The compactable composite resin (ALERT, Pentron Clinical Technologies) used had microglass fibers with an average of 6 µm diameter and 20 µm length [3]. CSS then penetrated in the spaces around the microglass fibers and the other hybrid fillers, improving the marginal integrity. Therefore, immediate CSS application was able to reduce the dye penetration at the dentin/cementum margins, but not eliminating it completely [11, 20, 23].

It was demonstrated that CCS can reduce composite wear [18, 20] and improve composite resin surface texture [6]. The influence of a re-application of CSS after polishing was also verified. Compared with other compactable composites ALERT (Pentron Clinical Technologies) was shown to be rough even after polishing [30, 31]. This characteristic was a consequence of microglass fibers incorporated into the hybrid composite matrix [31]. The application of Protect-It (Pentron Clinical Technologies) over ALERT (Pentron Clinical Technologies) improved the superficial roughness [32]. On the other hand the microhardness of the composite resin surface was reduced according to the CSS thickness layer [6]. Furthermore the re-application of CSS did not completely eliminate microleakage.

Although the immediate application of CSS, as well the CSS applications before and after resulted in a slight reduction of microleakage, the difference was not statistically different from the control group. The moment of CSS application influenced marginal microleakage in restorative dentin/cementum margins.

Conclusions

(1) The application of CSS did not eliminate microleakage.
(2) Immediate application of CSS as well as the application before and after finishing procedures reduced microleakage at the dentin/cementum margins when compared with the usual CSS application.

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