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Influence of Two Desensitizer Agents on the Microleakage of Adhesively Luted Ceramic Inlays

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ABSTRACT

Objectives: The purpose of this study was to evaluate the effects of two different desensitizers (Hemaseal & Cide and Aqua Prep F) on the microleakage of ceramic inlay restorations luted with adhesive resin cement.

Methods: Cylindrical Class V cavities were prepared on the buccal surfaces of thirty extracted human third molars. One of the desensitizers (either Hemaseal&Cide, Advantage Dental Products Inc. or Aqua-Prep F, Bisco) was applied to the cavities. Ten samples were used as controls. Ceramic inlays were fabricated using the heat-pressed glass ceramic technique (IPS Empress II). Inlay restorations were luted using adhesive cement (Variolink II, Ivoclar-Vivadent). The restorations were properly finished, stored in distilled water at 37°C for 24 h and subjected to 1000 thermal cycles. The microleakage scores were examined using a stereomicroscope at the 30x magnification after each sample was stained with 0.5% basic fuchsin. The data were analyzed using Kruskall Wallis and Mann Whitney U tests (P=0.05).

Results: Aqua-Prep F samples showed significantly higher microleakage scores at the enamel margins than did the Hemaseal & Cide and control groups (P<.05). Hemaseal & Cide application led to less microleakage than the other groups both at the enamel and dentin margins (P<.05).

Conclusions: Hemaseal & Cide desensitizer decreased the microleakage process at the enamel and dentin margins of inlay restorations luted with adhesive luting cement, while Aqua-Prep F increased the leakage scores at the enamel margins. (Eur J Dent 2011;5:77-83)

Key words: Desensitizers; Microleakage; SEM; Inlay restorations.

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INTRODUCTION

Adhesive resin luting cements are used extensively in dentistry to cement ceramic, cast metallic, and indirect composite restorations. A strong and durable bond is required in order to avoid the detachment of restorations and to prevent microleakage, postoperative sensitivity, secondary dental caries, and tooth fractures when such cements are used.

Despite recent developments in dental restorative materials and techniques, postoperative sensitivity is one of the well-known problems following restorative procedures.[1] There are several explanations for postoperative sensitivity. In clinical practice, enamel is generally removed with rotary instruments leading to the exposure of dentinal tubules. When the dentinal tubules are opened, the adverse effects of cavity preparation, such as excessive heat and dentin dehydration reach the pulp more easily.[2]

The clinical cavity depth has a significant influence on the appearance of postoperative sensitivity. In a previous study, caries profunda showed a four times higher risk of failure due to postoperative sensitivity compared to superficial or moderate caries.[3] Microleakage is one of the main factor affecting the incidence of postoperative dentistry.[4] If there is a discontinuity in the coating of the cavity wall by the bonding system or a micro-porous zone beneath the hybrid layer, hydrodynamic fluid shift or bacterial toxin penetration into dentin tubules may occur.[5] An approximate 1.6 μm/day of bacterial invasion through the gap between restoration and the cavity wall has been found to occur over time.[6] Bacteria can infiltrate the tubules in a relatively short period of time (up to 4 days). The odontoblastic process, collagen fibers, kinetics of tubular fluid, and immunological function do not seem to be sufficient to inhibit this process.[7]

The failure of restorations due to secondary caries have been reported in several clinical trials of direct and indirect restorations.[8-10] A prospective clinical study evaluating 64 indirect inlays/onlays over a period of 48 to 75 months with a mean time of 59 months reported one failure (2%) due to caries.[8] A clinical study evaluating the durability of a recently developed low-shrinkage resin composite indicated that secondary caries was the main reason for failure (8%) at a five-year evaluation.[9] A randomized clinical trial examining the clinical performance of composite resin materials used for fillings (n=56) and indirect inlays (n=84) reported two failures (4%) for fillings and four failures (5%) for inlays due to secondary caries at an 11-year follow-up.[10]

To reduce postoperative sensitivity, dentists increasingly use desensitizers based on hydroxyethyl metacrylate (HEMA), fluoride, and chlorhexidine gluconate after tooth preparation for restorations. Some ingredients of these desensitizers may induce chemical interactions with organic substances of the dentin that may consequently affect the sealing and bonding characteristics of the adhesive resin cement.[11-13] The function of fluoride present in dentin desensitizers is to seal the dentinal tubules with incorporation of mainly HEMA, which increases the infiltration ability of primers.[6]

Chlorhexidine is an antiseptic with a wide spectrum of action that has been used over the past two decades for the chemical control of bacterial plaque and the prevention of dental caries.[14] It is the most effective antimicrobial agent that can be used against *S. mutans*,[15] and it has a proven ability to delay bond degradation.[16] For this reason, chlorhexidine has been added to the desensitizers in recent years. Although there is no information concerning the effects of chlorhexidine-based desensitizers on the bonding performance of composites to tooth tissues, previous studies have shown that application of chx-containing cavity disinfectants before or after acid-etching procedures does not have a negative effect on the shear bond strength; in fact, this procedure may increase bond strength and durability.[11-13]

On the other hand, contradictory results have also been reported in the literature regarding the bonding effectiveness of desensitizers affecting by the blocking the dentin tubules with the crystals deposition. Some studies have demonstrated that the bond strength of composite to enamel and dentin was not reduced when these desensitizers were used.[17-19] However, some studies reported a reduction in bond strength caused by poor resin infiltration and micromechanical retention due to crystal precipitation of desensitizers on the enamel and dentin surface.[20-22] Nevertheless, a limited number of studies is available concerning the effect of desensitizers containing fluoride and chlorhexidine gluconate on the microleakage of adhesively luted ceramic inlays.

The aim of this study was to evaluate the effect of two different desensitizers (Hemaseal & Cide and Aqua Prep F) on the microleakage of adhesively luted ceramic inlays. The null hypothesis tested was that Hemaseal & Cide, including HEMA and chlorhexidine gluconate and Aqua Prep F, including both HEMA and sodium fluoride do not increase the microleakage when used prior to the bonding procedures of adhesively luted ceramic inlays.

MATERIALS AND METHODS

Thirty extracted caries-free human third molars were used in this study. Immediately after extraction, the teeth were scraped of any residual tissue tags, pumiced, and washed under running tap water. The teeth were stored in distilled water at +4°C until required. Standardized, non-beveled cylindrical Class V cavities were prepared on the buccal aspects of each tooth with round internal angles, 1 mm below the CEJ using cylindrical (3.8 mm in diameter and 1.8 mm in length) (041-038C, MDT Micro Diamond Technologies Ltd, Afula, Israel) and 6° conical diamond burs (702.8KR, Abrasive Technology, London, United Kingdom). Standardization of the cavity size was accomplished by using the cylindrical diamond burs in similar dimensions with the prepared cavities and employing the handpiece in a paralelometer during preparation. After preparation, the teeth were randomly divided into three groups.

Impressions were made with polyvinyl siloxane material (Imprint II VPS, 3M ESPE AG, Seefeld, Germany) and poured in a vacuum mixed polyurethane die material (Alpha Die MF, Schültz-Dental GmbH, Rosbach, Germany) according to the manufacturer's instructions. IPS Empress II ceramic inlays were fabricated according to the manufacturer's instructions and then glazed.

Ceramic inlays were etched with hydrofluoric acid for 20 s, and then a layer of silane coupling was applied to the ceramic bonding surface for 60 s and air-dried.

The enamel and dentin margins of inlay cavities were etched with the phosphoric acid gel (Uni-etch, Bisco, IL, USA) for 15 s and rinsed thoroughly with water for approximately 5 s and air-dried for 2-4 s to remove excess moisture leaving the dentin surface with a slightly glossy, wet appearance.

The desensitizers tested in this study were Aqua-Prep F (Bisco) and Hemaseal & Cide (Advantage Dental Products, Inc., Lake Orion, USA) (Table 1).

In Group 1, Aqua-Prep F was used before the application of primer. Two drops of Aqua-Prep F were dispensed into a mixing well. It was applied with a brush to the cavity surfaces. Aqua-Prep F was allowed to soak for 20 s and gently air dried to remove excess moisture to avoid pooling, especially at the internal line angles of the preparation. The resulting surface was wet and had a shiny appearance.

In Group 2, Hemaseal & Cide was applied with a brush as a desensitizer. The excess was removed by gently air drying to avoid pooling, especially at the internal line angles of the preparation. The resulting surface was wet and had a shiny appearance.

In Group 3, no desensitizer application was performed.

One drop of the primer (Syntac, Ivoclar Vivadent, Schaan, Liechtenstein) was applied to the cavity surfaces for 15 s and gently air-dried. A layer of bonding resin (Syntac) was applied with a brush for 10 s and spread gently with air. After application of enamel bonding agent (Heliobond, Ivoclar Vivadent) to the cavity and the bonding surface of the ceramic inlay restorations, the cavities were filled with Variolink II (Ivoclar Vivadent) and inlays were placed into the cavities using light pressure, and cured briefly (1–2 s) with light. Then the excess material was removed using a scaler. The restoration margins were covered with glycerin gel. The luting cement was light cured for 40 s from the buccal surface. The light activating unit was Optilux 501 (Kerr Orange, CA, USA), which was tested prior to each sample. The output of this unit did not drop 500 W/cm^2. After final polymerization, the glycerin gel was rinsed off.

Excess material was removed with finishing diamond burs and flexible discs. The restoration margins were finished with silicone polishers (Astropol -F, -P, Ivoclar Vivadent).

After cementation, specimens were stored in distilled water at 37°C for 24 h and then subjected to 1000 thermal cycles between the baths of 5 and 55°C, with a dwell time of 30 s. The teeth were subsequently coated with nail varnish 1 mm short of the restoration margins to seal open dentin tubules. The dye penetration test was conducted in a 0.5% basic fuchsin dye solution for 24 h. The teeth were then rinsed, and Class V restorations were sectioned into three parts longitudinally in a bucco-lingually plan with a slow-speed diamond blade (Struers, Ballerup, Danmark). The sections from the centers of the restorations were 2-mm-thick, while the other sections were 1-mm-thick. In this way, four surfaces (either mesial or distal surfaces of 1-mm-thick samples and both mesial and distal surfaces of 2-mm-thick samples) were obtained from one restoration for microleakage evaluation. One hundred twenty surfaces (n=40) were evaluated at 30x magnification under a stereomicroscope (Olympus Co., Tokyo, Japan) by two examiners who were calibrated prior to the study.

The extent of the microleakage was scored according to the following criteria:

0= no leakage visible,

1= penetration of dye along the cavity wall, but less than ½ the length,

2= penetration of dye along the wall, but short of the axial wall,

3= penetration of dye to and along the axial wall.

Leakage scores at occlusal and gingival margins for each group were compared with the non-parametric statistical tests, Kruskall Wallis and Mann-Whitney U. Significance was considered at the 0.05 level.

RESULTS

The test of intra-examiner and inter-examiner agreement resulted in a Cohen's kappa statistic of 0.85 and 0.88. The microleakage scores are shown in Table 2. Aqua-Prep F applied samples showed significantly higher microleakage scores at the occlusal margins than did the Hemaseal & Cide and control groups ($P<.05$). Hemaseal & Cide application led to less microleakage than the other groups, both at the enamel and dentin margins ($P<.05$). No significant difference was shown between the other groups for either enamel or dentin margins.

DISCUSSION

Most of the desensitizers are indicated by their manufacturers for use under restorative materials prior to applying primers and bonding agents in order to prevent postoperative sensitivity. Although they are good alternatives for reducing sensitivity, it is also important to evaluate the possible adverse effects of these desensitizing agents on the adhesion performance of restorative materials and the marginal quality of restorations.

In the present study, the effect of desensitizers on the microleakage of adhesively luted ceramic inlays was evaluated in Class V cavities. The reason for studying Class V cavities was that (1) Class V cavities have unfavorable C-factors, resulting in high contraction scores within an adhesively fixed resin material, (2) Class V restoration margins are located in enamel as well as in dentin, (3) preparation and restoration of Class V lesions are minimal and relatively easy, thereby somewhat reducing practitioner variability, and (4) it is easier to standardize the preparation of Class V cavities than Class II cavities.[23,24]

Different techniques have been described for studies of margin quality. The most widely accepted method is the dye penetration test.[25] In our study, 0.5% basic fuchsin solution was used for the dye penetration test. All restorations were

Table 1. Desensitizers used in this study.

Desensitizers	Active components	Manufacturer
Hemaseal & Cide	HEMA, 4% chlorhexidine gluconate, water	Advantage Dental Products, Inc, Lake Orion, USA
Aqua-Prep F	HEMA, 2% NaF	Bisco, IL, USA

Table 2. Results of microleakage test.

	Occlusal margin				Gingival margin			
	0	1	2	3	0	1	2	3
Hemaseal & Cide	26	12	2	-	31	4	1	4
Aqua-Prep F	7	15	5	13	21	11	5	3
Control	14	11	7	8	19	9	8	4

previously subjected to thermal cycling in order to subject the restorations to thermal expansion and contraction challenges. The different thermal expansion coefficients of tooth tissue from the restorative materials may lead to gap formation.[26] As such, to assess the *in vitro* performance of resin materials, thermal cycling is the common method used to simulate the long-term stresses to which the resin restorations are exposed.[27]

The microleakage scores of HEMA-based desensitizers at the dentin margins were less than those of the control group, although the differences were significant only between Hemaseal & Cide and the control group. The higher leakage scores for the control group might be related to the use of the acetone-based adhesive system. Previous studies have demonstrated that the moisture degree of dentin was effective on the bond strength of adhesive systems.[28-29] The water-based systems require a drier dentin surface, while acetone-based systems require a rather wetter dentin surface for improved bond strength.[28] Although the amount of dentin surface moisture was not assessed in this study, HEMA in the desensitizers might have contributed to improve the marginal quality of the experimental groups. HEMA-containing hydrophilic monomers rehydrate the collapsed collagen matrix caused by air-drying and facilitate subsequent resin infiltration into the interfibrillar spaces of demineralized dentin.[30,31] The addition of HEMA to water lowers the vapor pressure of water and prevents water from evaporating prematurely during rehydration of the collapsed dentin matrix.[32] In previous studies, HEMA significantly improved bond strength by enhancing the wetting of dentin.[30,31]

The better results for the Hemaseal & Cide group at the dentin margin as compared to the Aqua Prep F group may be attributed to the ingredients of those desensitizers other than HEMA, such as sodium fluoride and chlorhexidine gluconate. It has been shown that fluoride ions penetrating into the dentin enhance the mineralization of dentin; it can be anticipated that the presence of fluoride in the desensitizer may yield to obturation of dentinal tubules and impair the adhesion of resin-based cements to tooth tissues. Inconsistent results have been reported regarding the effect of fluoride ions on the adhesion performance of composites to dentin. Some authors have demonstrated that fluoride treatment on sound dentin decreased the bond strength to dentin,[22] while others have reported that fluoride application to demineralized did not interfere with the process of resin bonding.[19,33] In addition, it has been reported that pre-treatment of enamel and dentin with fluoride prior to the placement of a resin bonding agent produced no significant change in microleakage.[34]

Contrary to the inconsistent results in terms of the effect of fluoride ions on the adhesion performance of composite to dentin, chlorhexidine gluconate application prior to acid-etching did not reveal any adverse effects on immediate composite-adhesive bonds in dentin[11,12,35] and enamel.[35] Furthermore, chlorhexidine gluconate-based disinfectant did not adversely affect the shear bond strength of adhesively luted ceramics (Empress II) to dentin.[13] In addition, chlorhexidine has shown to have beneficial effects on the preservation of dentin bond strength as an MMP inhibitor, when applied prior to bonding with no further rinsing. When applied in this manner, the naked collagen fibrils were exposed to chlorhexidine that was then sealed into the fibrils by adhesive resins.[36]

According to leakage scores, Aqua Prep F demonstrated the worst results at the enamel margins. This may have resulted from the presence of sodium fluoride, which may precipitate and cover the demineralized surface, thus minimizing micromechanical retention. These results were in accordance with the results of a number of previous studies. Barcroft et al[20] reported a slight reduction in bond strength with the use of 2.0% aqueous sodium fluoride in the enamel samples. Meng et al[21] showed that the application of acidulated phosphate fluoride after the acid etching of enamel has an adverse effect on the orthodontic bond strength of human enamel. On the other hand, some authors have reported that the exposure of enamel to sodium fluoride, stannous fluoride, or acidulated phosphate fluoride has no adverse effect on *in vitro* bond strength and microleakage between the enamel and composites.[17,18,33,34]

The application sequence of the disinfectant is also an important factor to be considered. Some clinicians prefer to apply disinfectants after tooth preparation,[19] while the others prefer to apply them after etching.[37,38] In previous studies, the oxalate-based desensitizers with desensitizing mechanism that are similar to fluoride-based ones reduced the bond strength of adhesive systems when they were applied before the dentin was acid-etched.[39,40] This result may be explained by the presence of acid-resistant calcium oxalate crystals on the dentin surface that may prevent etching and the penetration of adhesive resins into the dentin surface. In this situation, additional enamel etching to remove these crystals and increase the microretentive topography was recommended.[40] In the present study, the desensitizers were applied after acid-etching procedures and additional etching was not performed. This was done because the manufacturers recommend the use of both desensitizers after etching and do not propose additional etching after the application of desensitizers.

CONCLUSIONS

Within the limitations of this study, while the use of Hemaseal & Cide decreased the microleakage process at the enamel and dentin margins of IPS Empress II inlay restorations luted with an adhesive luting cement, Aqua-Prep F increased the leakage scores at the enamel margins. The increased microleakage at enamel margins may result from the presence of sodium fluoride in this desensitizer, which may precipitate and cover the surface, reducing the micromechanical retention between resin monomers and enamel.

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