Microleakage study of CEREC III restorations

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Abstract  Objective: The purpose of this study is to investigate the effect of three resin cements on the adaptation of CEREC III (Ceramic Reconstruction) and to measure the degree of microleakage between resin cement and tooth structure and also between resin cement and CEREC III restorations which fabricated by using CAD/CAM system and luting them at the same time.

Materials and methods: Twenty-four cavities were prepared (Inlay) on the mesial-occlusal-distal surfaces of twenty-four human freshly extracted premolars. CEREC III (Sirona) is used to prepare ceramic restorations by milling blocs (Vita Blocs Esthetic Line for CEREC/inlab German made) with 1M1 shade and K12. Suitable Ceramic restorations for cavities were obtained.

All samples of ceramic restorations were divided into three groups and were cemented with three types of luting resin cement as the following: Bistite II DC, Perma Flo DC and Multilink Automix, then the Plasma Arc light cure unit was used to cure cement. All restorations were finished and immersed in 0.5% basic fuchsine solution for 24 h. The specimens were cut in the mesio-distal direction and then evaluated for microleakage.

Results: The data were analyzed using chi-square statistical test with significance 0.05. A relationship between the degree of microleakage and the type of cement at interface tooth structure/luting cement has been found. No statistical difference was found between the type of cement and microleakage degree at interface luting cement/CEREC III restoration.

Conclusion: It was concluded that the degree of microleakage at interface CEREC III restoration/resin cement was less than microleakage at interface resin cement/tooth structure.
acid, silane and adhesive treatment with Panavia 21 cement gave significantly higher bond strength [29]. A recently developed material is described as self-adhesive universal resin cement. The objective of developing this cement was to combine the ease of handling offered by glass-ionomer cements with the favorable mechanical properties [22], attractive esthetics [15] and good adhesion of resin cements [19]. Most resin cement kits contain both an adhesive (dentin bonding agent) for bonding to tooth structure and dual-polymerizing cement (composite) for bonding to the restoration. When bonding ceramic to tooth structure, two different interfaces need to be considered: The dentin/adhesive interface and the ceramic/cement interface [16]. Frankenberger et al. [10] compared the dentin bond strength and marginal adaptation of direct resins and ceramic inlays. They have found that pre-polymerization of the bonding adhesive increased dentin bond strengths in all situations. Ideally, the margin or interface between the tooth and the restorative material should be sealed to prevent microleakage and the resultant caries that will occur. For all-ceramic inlays, microleakage is an important consideration for preserving the marginal seal due to less than ideal marginal adaptation of the porcelain material [20]. Moreover, with the introduction of several new resin cements, there is confusion among clinicians about which product and technique to use. It is well established that the type of cementing agent used for bonding has a bearing microleakage [23,26]. The purpose of the current study is to investigate the effect of three different resin cements on the adaptation of CEREC III restorations and to measure the degree of microleakage between resin cement and CEREC III restorations which fabricated by using CAD/CAM system and luting them at the same time.

2. Materials and methods

2.1. Preparation of cavities

Twenty-four caries free extracted human maxillary premolars were collected. All teeth were stored in saline, at room temperature immediately after extraction. The calculus was removed using scaler. Then the teeth were cleaned and polished using a rotating brush and pumice. After sealing the root apices with wax, they were mounted in gypsum bases.

The preparation design of the cavities for the ceramic inlays was based on the concept of standard class II mesio-occluso-distal (MOD) preparations, with a flat pulp wall. Then all angles of cavities were rounded using diamond burs (H835 010 Meisinger). The depth of the preparation was about 2 mm, and all cavity margins were located in enamel.

2.2. CEREC scan

After completion of all preparations, the surfaces were evenly covered with anti reflection powder (CEREC Optispray, Sirona, Germany) to facilitate the scanning process. Then an optical impression was taken using the intraoral camera of CEREC III system (Sirona Dental Systems, Bensheim, Germany). Data were stored using the computer software (CEREC 3D V3.05). After designing each restoration the information was sent to the milling unit, which utilized two diamond burs (step and cylinder pointed), and Vita blocks (Vita blocs esthetic line for CEREC EI-1M1C K12 Vita Zahnfabrik) were used as ceramic blocks. After the scanning process the powder was removed using air–water spray for 30 s and the teeth were dried. The restoration was milled in a few minutes in a compartment of the chairside unit.

2.3. Adhesive luting procedures

The prepared and cleaned specimens were randomly assigned to three groups (n = 8). The three resin-cements were selected from different companies as in Table 1, and each group was cemented, with the selected resin-cements, according to the manufacturer’s instructions as the following:

The first group was luted with Bistite II DC (Tokuyama) as the following: After etching tooth surface with phosphoric acid, Primer1 was applied after mixing one drop each of Primer 1A and 1B with disposable brush onto both enamel and dentin cavity surface using sponge. Primer 1 was applied several times during 30 s application time, and then air dried gently for 2–3 s. The Primer 2 was applied on the treated tooth surface which was previously coated with Primer 1. It was left for 20 s on the surface, then dried gently for 3–5 s. The bottom side of the inlays was roughened with grinding with diamond bur, and then dried. TOKUSO CERAMIC Primer A and B was placed on the bottom side of ceramic for 10 s prior to bonding. The pastes A and B were mixed evenly for 10 s and the mixed cement was applied on the bottom side of the inlays, then the restoration was placed on the tooth with a pressure.

The second group was luted with Perma Flo DC (Ultradent) as the following: First the inside surface of the restoration was etched, with hydrofluoric acid for 1 min, and then it was rinsed and dried. The etch surface was silanated with Prema Flo DC silane for one minute and then dried. Tooth surface was etched, and then coated with Primer A for 10 s followed with 2–4 drops of primer B for 10 s also, until shiny surface was observed. The thin layer of Perma Flo DC cement was applied in the restoration and placed.

The third group was luted with Multilink Automix (Vivadent) as the following: The inside of the inlays was roughened using a finishing diamond. Then they etched with Total Etch gel for 60 s. The etching gel was rinsed thoroughly. Monobond-S was applied to the surface with a brush for 60 s. The mixed Multilink Primer A and B was applied with a micro-brush on the entire preparation surface, starting from the enamel and scrubbing with slight pressure for 15 s. The recommended reaction time is 30 s on the enamel, and 15 s on the dentin. The applied primer was dried with air. The Multilink Automix was applied directly to the inner surface of the restoration. The restoration was placed on the tooth with a pressure.

After removal of excess luting cement, the samples were light cured with plasma arc light curing unit (2500 mW/cm²) for 10 s on each side. Finishing of the margins was performed with polishing disks (Porcelain laminate Polishing Kit).

2.4. Evaluation of microleakage

For evaluating microleakage of the specimens, the selected teeth were covered with two coats of nail-varnish, leaving a 1 mm varnish-free margin around the CEREC III restoration, and then those specimens were immersed in a 0.5% Water
solution of basic fuchsin for 24 h and rinsed for 5 min with water. Then specimens were sectioned longitudinally with two parallel cuts in mesio-distal direction with a water-cooled low-speed diamond.

Dye penetration was measured on the gingival margins of mesio-distal surfaces of inlay. The degree of dye penetration was identified according to Hilton and Ferracane [12], the following numerical criteria: 0 = no marginal leakage, 1 = dye penetration that extends less than or up to 1/2 the distance to dentin-enamel junction, 2 = dye penetration that extends more than 1/2 the distance and up to, but not past the dentin-enamel junction, 3 = dye penetration that extends past dentin–enamel junction, up to the junction of the gingival and axial walls, but not including the axial wall, 4 = dye penetration that involves the axial wall. Each section was examined under a stereomicroscope at 40× magnification.

2.5. Statistical analysis

For comparison between the different groups the chi-square statistical test was used, and also Microsoft Excel 2007 was used. The data of microleakage investigation were analyzed using chi-square statistical test at a significance level of \( p < 0.05 \).

3. Results

Figs. 1 and 2 show the microleakage data of all groups. Fig. 1 shows the microleakage frequency scores at luting cement/tooth structure interface in the three groups. The third group obtained the lowest leakage, followed by first and second groups, while second group showed the highest leakage at luting cement/tooth structure interface. The chi\(^2\) test \( (p < 0.05) \) shows that there is a relationship between the degree of microleakage and the type of luting cement at luting cement/tooth structure interface. Fig. 2 shows microleakage frequency scores at luting cement/CEREC III restoration interface surface in the three groups. The first group obtained the lowest leakage, followed by the second and third groups, while no group showed the highest microleakage at luting cement/CEREC III restoration interface. The chi\(^2\) test \( (p < 0.05) \) shows that no statistical difference was found between the type of luting cement and microleakage degree at luting cement/CEREC III restoration interface. The degree of microleakage at luting cement/CEREC III restoration is less than luting cement/tooth structure interface.

### Table 1: Luting materials.

<table>
<thead>
<tr>
<th>Group</th>
<th>Luting system</th>
<th>Components</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>Bistite II DC</td>
<td>- Primer 1 (A&amp;B) phosphoric acid, monomer, acetone, alcohol, water, initiator</td>
<td>Tokuyama, Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Primer 2 HEMA, acetone, initiator</td>
<td>Ultradent, USA</td>
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<tr>
<td></td>
<td></td>
<td>- Tokuso Ceramic primer (A&amp;B) silane coupling agent, phosphoric acid, monomer, alcohol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Resin Cement Pastes (A&amp;B) silica-zirconia, dimethacrylate, MAC-10, initiator</td>
<td></td>
</tr>
<tr>
<td>G2</td>
<td>Perma Flo DC</td>
<td>- Ultra-Etch 35% phosphoric acid</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- Primer A&amp;B Ethanol Acetone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Perma Flo DC luting Bis-GMA, Benzoyl Peroxide, Tertiary Amine</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- Ultradent Porcelain Etch hydrofluoric acid</td>
<td></td>
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<td></td>
<td></td>
<td>- Ultradent Silane mono-component solution</td>
<td></td>
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<tr>
<td>G3</td>
<td>Multilink Automix</td>
<td>- Multilink Automix: dimethacrylate, HEMA, barium glass, ytterbium trifluoride, spheroid mixed oxide</td>
<td>Ivoclar, Vivadent Liechtenstein</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Multilink Primer A&amp;B: Initiators, HEMA, phosphoric acid, acrylic acid monomer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Monobond-5:3 methacryloxy propyl-trimethoxysilane water/ethanol, acetic acid</td>
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</tbody>
</table>
4. Discussion

The new manufacturing techniques introduced in dentistry are the CAD/CAM technique and the commonly used pressable ceramics. The CAD/CAM technique was introduced into dentistry at the beginning of the eighties and different systems have been presented [6]. The main advantages of CAD/CAM inlays are related to the possibility to restore cavities in a single visit, on the other hand labside-manufactured inlays are supposed to have a better fit [3,4,5; Jedynakiewicz and Martin, 2001]. Ceramic restoration is cemented with resin cement system, the ceramic should be etched with hydrofluoric acid, and silane and adhesive should be applied prior to cementation [29]. In this study the three types of luting cements, which used to lute CEREC III restoration, were evaluated and examined the marginal adaptation of these types of cement by using dye penetration technique, according to some studies which have been reported on indirect(dye penetration) methods of investigation into the marginal gaps[9,8]. Detection of microleakage can be accomplished with a number of techniques including bacteria, chemical or radioactive tracer molecules, fluid permeability and dye penetration [1]. The most common technique is the use of dye, the penetration of which is determined after sectioning of the specimen with a magnifying aid. Microleakage of restoration may be the starting point of secondary caries and the treatment failure [17]. In a recent study the Multilink Automix resin cements showed the lowest microleakage results at the cement/tooth structure interface. The Bistite IIDC and Perma Flo DC showed a significantly higher microleakage value than Multilink Automix at luting cement/tooth structure. So there was a relationship between the degree of microleakage and the type of luting cement. The resin composite-based luting materials were not able to chemically bond to tooth structure, according to a similar acid–base process. Their sealing ability seems to be primarily based on the micromechanical overlap in the conditioning tooth crystalline structure [30]. None of the three luting cements prevented dye penetration. For all tested luting cements, dye percolation was significantly larger at the tooth structure/ luting cement interface in all groups. The luting quality of dental restorations to tooth structure strongly depends on the properties of the dental cements and their corresponding bonding systems. For resin cements the tooth pre-treatment with acid, primer and bonding is essential, because it influences the condition of the dentin smear layer. The Multilink Automix with Multilink Primer A and B show the best bonding results, which were obtained by dissolving or removing the smear layer and by formation of resin tags. Their good superficial integrity and low microleakage express the good adaptation between restoration and tooth, even with no chemical bonding between cement and tooth structure.

In this research study CEREC III restoration cemented with resin luting cement shows that the Bistite II DC obtained the lowest leakage, followed by the Perma Flo DC and Multilink Automix. There was no statistical difference found between the type of cement and microleakage degree at the luting cement/CEREC III restoration interface.

Kupiec et al. [14] reported that best bonds were obtained immediately after bonding and at three months when silane was used. Sjögrem et al. [24] reported no significant differences between dual-polymerized or auto-polymerized composite resin luting agent were clinically evaluated. These findings were confirmed by Van Dijken et al. [25] who investigated the use of a dual-polymerized and an auto-polymerized composite resin luting agent in restoration with extensive tooth bonded ceramic coverage. Frankenberger et al. [10] studied the dentin bond strength and marginal adaptation of direct resins and ceramic inlays. They found that pre-polymerization of the bonding adhesive increased dentin bond strengths in all situations. Peters and Meiers [21] reported, that light-polymerization increases the bond between dual-cure resin cements and dental restorative materials. Gemalmar et al. [11] demonstrated that the marginal gap of porcelain inlays was larger when dual cure resin cement was used for bonding. White and Kipnis [28] investigated the effect of five different luting agents on the marginal fit of cast single-crown restorations bonded to extracted premolars in vitro observed no significant marginal gap differences in the pre-bonding stage, but reported that significant differences did emerge after cementation. This finding may conceivably be due to resin cements rapidly gaining viscosity in the process of curing. For this reason, White et al. [27] recommended that resin cements should be applied swiftly and carefully in clinical practice, and that indirect restorations should be inserted with considerable pressure. In this study the degree of microleakage at the CEREC III restoration/luting cement interface was less than the luting cement/tooth structure interface. Although no microleakage occurred at CEREC III restoration/luting cement interface, the use of ceramic silane should be taken into consideration clinically when ceramic restorations are cemented using polymer based cements, because there is a chance of better marginal seal when using hydrofluoric acid.

5. Conclusion

Summarizing the results of this study, we may conclude that in CEREC III restoration:

- less microleakage was found between CEREC III and resin luting cement, and the Bistite IIDC was the best cement among others.
- Although there was microleakage between resin-cement and tooth structure, the Multilink Automix was the best cement among others.
- No statistical difference was between type of resin-cement and marginal adaptation of CERECIII restoration, but there was statistical difference between the degree of microleakage and type of cement at cement/tooth structure interface.

Thus it is important to note that improvements in both CEREC technology and luting techniques promise to produce even better results for restorations being placed today and in the future. It was concluded that the degree of microleakage at the CERECIII restoration/luting cement was less than luting cement/tooth structure.

References

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