Effect of Contamination with Impression Materials on Shear Bond Strength of Porcelain to Immediately Sealed Dentin

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Abstract:
Objective: The aim of the present study was to evaluate the effect of two impression materials on the shear bond strength of porcelain to immediately sealed dentin.

Materials and Methods: Smooth dentin surfaces of 45 extracted premolars were immediately sealed with Adper Single Bond adhesive agent. Forty-five porcelain specimens were also prepared. The teeth were divided into one control and two experimental groups. In control group, an adhesive layer to dentin was applied and feldspathic porcelain specimens were bonded to dentin with Relay X dual-curing cement. In one experimental group, the teeth were embedded in condensational silicon (Speedex) and in the other group in polyether (Impregum Soft) impression materials before bonding the porcelain specimens as in the control group. Shear bond strengths were measured using a universal testing machine. Fracture modes were evaluated under a stereomicroscope. Data was analyzed using one-way ANOVA, Tukey, and chi-square tests (α=0.05).

Results: No significant differences existed between bond strength of the control and condensational silicon groups (P=0.31). Bond strength was significantly lower in polyether group in comparison with the control (P<0.0005) and condensational silicon groups (P=0.002).

Conclusion: Contamination with polyether impression material adversely affects the shear bond strength of porcelain to immediately sealed dentin.

Key Words: Dentin; Impregum; Silicon;

INTRODUCTION
In large cavities, indirect conservative restorations in which the main interface of adhesive is with dentin are the treatment of choice [1]. In these cases, the final strength of the tooth-restoration complex is highly dependent on adhesion and hybridization methods for dentin preparation [2]. Long-term clinical trials have shown that porcelain veneers partially bonded to dentin are at increased risk of failure [3,4]. Newly scraped dentin is an ideal substrate for bonding. Therefore, contamination of dentin before final restoration of a tooth results in a lower dentin capability for bonding, leading to lower bond strength (BS), failure of hybridization process and post-treatment sensitivity [5-7]. Dentin-resin hybridization is adversely affected by contamination of dentin [2,8,9] and collapse of the hybrid layer before polymerization of the resin [2,5].

According to some studies control of the above-mentioned phenomena can be achieved through sealing dentin immediately after preparation of the cavity and before impression taking [10,11]. Several technical and practical reasons exists supporting the use of
this method called dual bonding or immediate dentin sealing (IDS) before impression taking [2,12].

Despite such advantages as improved bond strength, less gap formation, decreased bacterial leakage, and reduced dentin sensitivity, one consideration to be reflected upon in this method is the presence of an oxygen-inhibited (OI) layer on the bonded surface of dentin. This layer is a soft, sticky, and superficial layer with a liquid-like consistency, which forms on the surface of light- or self-polymerizing resins and is composed of non-reacted monomers and oligomers [13]. This layer gives rise to an interdiffusion zone at the interface of materials, where copolymerization takes place to create a chemical bond, and enhances the incremental reaction [14]. Several studies have examined the effect of OI layer on bonding and have reported increased [15,16], unchanged [17,18] and decreased [19-22] BS of composite layers. According to Magne [10] in IDS technique, a possibility of interference of this layer with impression materials also exists.

It is probable, in case of interference, that the BS of porcelain to immediately sealed contaminated dentin is affected. Therefore, the aim of the present study was to examine the interference of two types of impression materials with the OI layer and its effect on the shear bond strength (SBS) of porcelain to immediately sealed dentin.

MATERIALS AND METHODS
In the present in vitro study, 45 intact caries-free human premolars, which had been extracted for orthodontic reasons, were selected. Transillumination technique confirmed absence of any restorations or cracks in the specimens. The specimens were stored in a 0.5% chloramine T solution at 4°C for a month. After cleansing their surfaces with water and a brush, the facial surface of each tooth was ground, using 600 grit silicon carbide abrasive (Gelva, Achilles, Holland), so that the dentin was completely exposed.

After etching the specimens with 35% phosphoric acid (Scotch Bond Etchant; 3M ESPE, St. Paul, MN, USA) for 15 seconds, and rinsing and removing the residual water by cotton pellets, the dentin surface was coated with two layers of adhesive (Adper Single Bond; 3M ESPE, St. Paul, MN, USA) according to manufacturer's instructions. Then the adhesive was polymerized for 10 seconds using a light-curing unit (Astralis 7; Ivoclar Vivadent AG, Liechtenstein) with an intensity of 400 mW/cm², while the curing tip was kept per-
To the surface 1 mm away from it. Then the specimens were randomly divided into three groups. Forty-five porcelain specimens were prepared using feldspathic porcelain powder (Ceramco3; Densply Ceramco, Burlington, USA) as 3 mm × 2 mm cylinders [23], using a uniform method. In group 1, the surfaces of porcelain specimens were etched using 4% hydrofluoric acid (Bisco; Schaumburg, IL, USA) for 4 minutes. Then the porcelain primer (Bisco; Schaumburg, IL, USA) and the Adper Single Bond adhesive were applied to porcelain and immediately sealed dentin surfaces according to manufacturer's instructions. Finally, the porcelain specimens were luted to the dentin using resin cement (Rely X ARC; 3M ESPE, St. Paul, MN, USA) and polymerized for 60 seconds from all four sides using a light-curing unit (Astralis 7) with 400 mW/cm² intensity.

In group 2, the specimens with immediately sealed dentin of the facial surface, were imbedded in condensational silicon impression material (Speedex; Coltene AG, Altstatten, Switzerland) before bonding porcelain specimens. Putty and wash were prepared at room temperature according to manufacturer's instructions. After taking the specimens out, another layer of bonding material was applied. The other stages were the same as described for group 1.

The only difference between groups 2 and 3 was that in group 3 polyether impression material (Impregum Soft; 3M ESPE AG, Seefeld, Germany) was used.

After storing the bonded specimens for 24 hours in 37°C distilled water, thermocycling (500 cycles at 5°C to 55°C, SD=2°C, interval time=10 s, dwell time=30 s) was performed. The specimens were mounted vertically on a plastic mold containing self-polymerizing acrylic resin up to 1.5 mm apical to CEJ, which was then clamped vertically in the base of testing machine. Each specimen was subjected to a shearing force applied by a universal testing machine (Hounsfield Test Equipment; H5K-S model, England) at a strain rate of 0.5 mm/min (Fig 1). The blade touched the porcelain-tooth interface, and the BS at failure was measured. SBS was calculated in Mega Pascal (MPa). A stereomicroscope was used to evaluate fracture modes at magnification ×40. Failure modes were evaluated for both cohesive (in dentin or porcelain) and adhesive (interface) fractures. One-way ANOVA was used to analyze differences in SBS between groups and a post hoc Tukey test was used for the two-by-two comparison of the groups. Chi-square test was used to compare fracture modes (α=0.05).

RESULTS

SBS of porcelain to immediately sealed dentin in the three groups of study is shown in Table 1. Significant differences existed in SBS between the study groups (P<0.0005). According to Tukey test, no significant differences existed between BS of the control and condensational silicon groups (P=0.31). BS was significantly lower in polyether group in comparison with the control (P<0.0005) and condensational silicon groups (P=0.002). The results of the chi-square test regarding fracture modes demonstrated that although there were no sig-

<table>
<thead>
<tr>
<th>Group</th>
<th>Frequency</th>
<th>Mean (SD)</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15</td>
<td>13.70 (3.93)</td>
<td>20.25</td>
<td>7.26</td>
</tr>
<tr>
<td>Condensation Silicon</td>
<td>15</td>
<td>12.08 (2.78)</td>
<td>17.56</td>
<td>8.28</td>
</tr>
<tr>
<td>Polyether</td>
<td>15</td>
<td>8.15 (1.92)</td>
<td>12.30</td>
<td>5.77</td>
</tr>
</tbody>
</table>
significant differences between the groups (P=0.08), there were fewer cohesive fractures (in the porcelain) (Fig 2) in polyether group compared to control and condensational silicon groups.

DISCUSSION
The results of the present study demonstrated a lower porcelain-to-dentin SBS in immediately sealed dentin that had been in contact with a polyether impression material (Impregum Soft) in the presence of OI layer, compared to the control group and the condensational silicon impression material group.

Adper Single Bond adhesive contains Bis-GMA, HEMA, and dimethacrylate, which have dangling OH groups in their chains [24]. These groups are ready to establish weak hydrogen bonds with the oxygen in the adjacent molecules [25,26]. In addition, despite decreased levels of photo-initiator in the OI layer [15], there are monomers and non-reacting oligomers, which in the absence of oxygen as the active free radical, are ready for reaction [27]. The main polyether chain is a copolymer of ethylene oxide and tetrahydrofuran, which exists as aziridin rings in the branching end of polyether molecules. These rings pave the way for cross-linking and setting with the aromatic initiating factor (sulfonate ester) [28]. At first, the initiator is dissociated and a carbocation (R+) is produced, which immediately attacks the highly reactive group (amine ring) in polyether molecules.

The quaternary ammonium salt, especially with a triple ring, is highly unstable, resulting in a phenomenon referred to as Hofmann's elimination [29,30]. Therefore, with the elimination of the ring and migration of the electron pair, a double bond is formed between C and C and an acrylate group is formed. The acrylate group easily forms strong chain-to-chain bonds with Bis-GMA chain through acrylate addition. All these can be present in an unpolymerized layer of the adhesive. If this layer is polymerized, it will be less probable to observe free radicals, Hofmann's elimination and, as a result, cross-linking reactions. Since there are no active amine rings, there would be no Hofmann's elimination phenomena when siloxane impression materials are used, and only weak hydrogen bonds will be responsible for the presence of cross-linkings [25,26]. Probably, in case of hydrogen bonding between dangling OH groups of monomers and oligomers of the OI layer and the oxygen of the polyether molecule on one hand, and cross-linking mediated by Hofmann's elimination on the other hand, the possibility of the formation of proper bonding between the two adhesive layers will decrease. This will be manifested as a decrease in SBS.

Given the structure of silicones, the odds of the occurrence of these reactions is low, except for weak hydrogen bonds and maybe that was the reason why no significant differences were observed between this group and the control group regarding the means of SBS of porcelain to immediately sealed dentin.

Although Magne and Belser [12] recommended the use of glycerin gel to prevent the reaction between the OI layer of the dentin adhesive and the impression material, probably this depends on the kind of the impression material. Further studies are required on the interference of different impression materials with the surface layer of different types of dentin adhesives with or without the OI layer. Moreover, the effect of various thicknesses of OI layer, as well as the effect of different types of surface cleaning methods of sealed dentin surface layer before bonding should be considered especially when polyether impression materials and temporary cements are used.

CONCLUSION
Within the limits of the present study, it can be concluded that contamination with polyether impression materials has adverse effects on the SBS of porcelain to immediately sealed dentin.
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