

# Does immediate dentin sealing influence the polymerization of impression materials?

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## ABSTRACT

**Objectives:** The objective of the following study is to evaluate the interaction between the resin materials used in immediate dentin sealing (IDS) techniques and impression materials with two different techniques to eliminate the oxygen-inhibition layer. **Materials and Methods:** The occlusal dentin surface of 35 human molars was exposed. The teeth were used in two Groups: Group 1 – Impression with Express XT; Group 2 – Impression with Impregum. Groups 1 and 2 were divided into 14 subgroups: Groups 1a and 2a – Control groups; 1b and 2b – IDS with Clearfil SE Bond (CSE); 1c and 2c – IDS with CSE + additional polymerization with glycerin jelly; 1d and 2d – IDS with CSE + alcohol; 1e and 2e – IDS with CSE and Protect Liner F (PLF); 1f and 2f – IDS with CSE and PLF + additional polymerization with glycerin jelly; and 1g and 2g – IDS with CSE and PLF + alcohol. Five teeth were used in each experimental group, and the tooth surface was photographed using a digital camera. **Results:** Small quantity of unpolymerized impression material remained attached to the CSE or to the PLF in Groups 1b and 1e. Groups 1c and 1d prevented the interaction. Small quantity of polymerized impression material remained attached to the CSE or to the PLF for Groups 2b and 2e. The same interaction was observed for Groups 2c and 2d. For Groups 2c and 2f, no interactions were observed. **Conclusion:** Resin materials interacted with impression materials. The application of glycerin jelly and alcohol prevented the interaction of CSE with Express XT and PLF with Impregum; however, these treatments were not completely effective in preventing the interaction of CSE with Impregum and PLF with Express XT.

**Key words:** Immediate dentin sealing, impression materials, oxygen-inhibition layer

## INTRODUCTION

During tooth preparation for indirect restorations such as inlays, onlays, veneers, and crowns, a significant area of dentin is exposed. To avoid problems such as dentin contamination by provisionalization<sup>[1,2]</sup> and hybridization failure sensitivity,<sup>[3]</sup> a technique called immediate dentin sealing (IDS) was suggested in the early 1990s.<sup>[4]</sup> This technique consists of the application of an adhesive system immediately after tooth

preparation and before taking the impression. Another IDS technique was developed in which a sealing film is applied to the dentin surface immediately after tooth preparation using an adhesive system and a low-viscosity composite resin.<sup>[5,6]</sup> It is believed that this layer of low-viscosity composite resin isolates the underlying hybrid layer and consequently, aids in preserving the dentin seal.<sup>[7]</sup> Therefore, IDS techniques are based on the principle that adhesive systems bond better to freshly prepared dentin,<sup>[1,2]</sup> thus

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protecting the dentin – pulp complex and preventing or decreasing sensitivity and bacterial leakage during the provisional stage.<sup>[8,9]</sup>

When using the IDS techniques, the impression is taken after the application of the resin material on the dental substrate. This step is critical because the impression material can interact with the outer resin layer,<sup>[3]</sup> which is unpolymerized due to the oxygen-inhibition of the radicals that initiate the polymerization reaction.<sup>[10,11]</sup> Different techniques have been suggested to reduce or eliminate the oxygen-inhibition layer (OIL), such as the application of glycerin jelly followed by an additional light cure<sup>[12]</sup> or the use of a cotton pellet soaked in alcohol.<sup>[13]</sup> However, no study has compared these two techniques before an impression with vinyl polysiloxane and polyether.

The aim of this study was to qualitatively evaluate the interaction between the resin materials used in the IDS techniques and impression materials when two different techniques to reduce/eliminate the OIL are applied. This study was based on the hypothesis that these techniques do not eliminate the interaction between impression materials and resin materials.

## MATERIALS AND METHODS

Thirty-five unerupted human third molars, which were extracted for therapeutic reasons, were obtained

from the tooth bank after the approval of the Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul. The teeth were cleaned of gross debris and stored in distilled water at 4°C. The water was changed every week, and the teeth were used in the study within 6 months. The roots were mounted in self-cured acrylic resin, and the occlusal enamel surface was removed with a diamond disc mounted in a low-speed laboratory cutting machine (Labcut 1010, Extec Corp., London, UK) under cooling conditions. The rest of the enamel was removed with 400-grit silicon carbide abrasive paper in a polishing machine (DPU-10, Panambra, São Paulo, SP, Brazil) under water. The superficial dentin was exposed and finished with 600-grit silicon carbide abrasive paper in the polishing machine, and a flat dentin surface was obtained.

After polishing, the teeth were randomly divided into seven Groups (*n* = 5) to be used in Group 1 (Impression with Express XT). The teeth were used again for Group 2 (Impression with Impregum) after remotion of the resin material with 600-grit silicon carbide abrasive paper. Table 1 shows the materials used in the present study.

Express XT vinyl polysiloxane impression material was used in Group 1, and the following subgroups were assigned [Figure 1]:

- Group 1a: Unsealed tooth surface
- Group 1b: IDS with Clearfil SE Bond (CSE). SE Primer was first applied to the tooth surface for 20 s

**Table 1: Materials used in the study**

Material	Composition	Manufacturer
CSE	Self-etch primer: 10-MDP, HEMA, hydrophilic dimethacrylate, photo-initiator, water Adhesive: 10-MDP, Bis-GMA, HEMA, hydrophilic dimethacrylate, microfiller	Kuraray Medical Inc., Tokyo, Japan
PLF	TEGDMA, Bis-GMA, methacryloyl fluoride-methyl, methacrylate copolymer	Kuraray Medical Inc., Tokyo, Japan
Express XT	Heavy paste - base paste: Alumina, cristobalite, vinyl polidimetilsiloxane, hydrocarbons, dimethyl polysiloxane copolymer, quartz, amorphous silica Paste catalyst: Alumina, cristobalite, vinyl polidimetilsiloxane, hydrocarbons, amorphous silica Slurry viscosity average - paste base: Vinyl polidimetilsiloxane, cristobalite, dimethyl polysiloxane copolymer, silicon-treated silica, polyethylene, siloxane Paste catalyst: Vinyl polydimethylsiloxane, cristobalite, silica treated with silicon, polydimethylsiloxane, blue pigment	3M ESPE, Saint Paul, Minnesota, USA
Impregum Soft Medium-Body	Base paste: Copolymer of ethylene oxide and tetramethylene oxide, diatomaceous earth, triglycerides, dibenzyl toluene, substituted imidazole, copolymer of ethylene oxide and propylene oxide, flavorings and colorings Catalyst paste: Salt sulfonic ester, citric acid, silica, diatomaceous earth, copolymer of ethylene oxide and propylene oxide, and ethyl polymeric dye	3M ESPE, Saint Paul, Minnesota, USA
Glycerin jelly	Water, glycerin, propylene glycol, hydroxyethylcellulose, monobasic sodium phosphate, methylparaben, dibasic sodium phosphate, propylparaben	Johnson and Johnson, New Brunswick, New Jersey, USA
Alcohol	70% ethyl alcohol	Hidralcol, Jundiaí, SP, Brazil

HEMA: Hydroxyethylmethacrylate, TEGDMA: Triethylene glycol dimethacrylate, Bis-GMA: Bisphenol-glycidyl methacrylate, 10-MDP: 10-methacryloyloxydecyl dihydrogen phosphate, CSE: Clearfil SE Bond, PLF: Protect Liner F, Jelly: Glycerin jelly followed by an additional light cure, Alcohol: Cotton pellet soaked in 70% alcohol

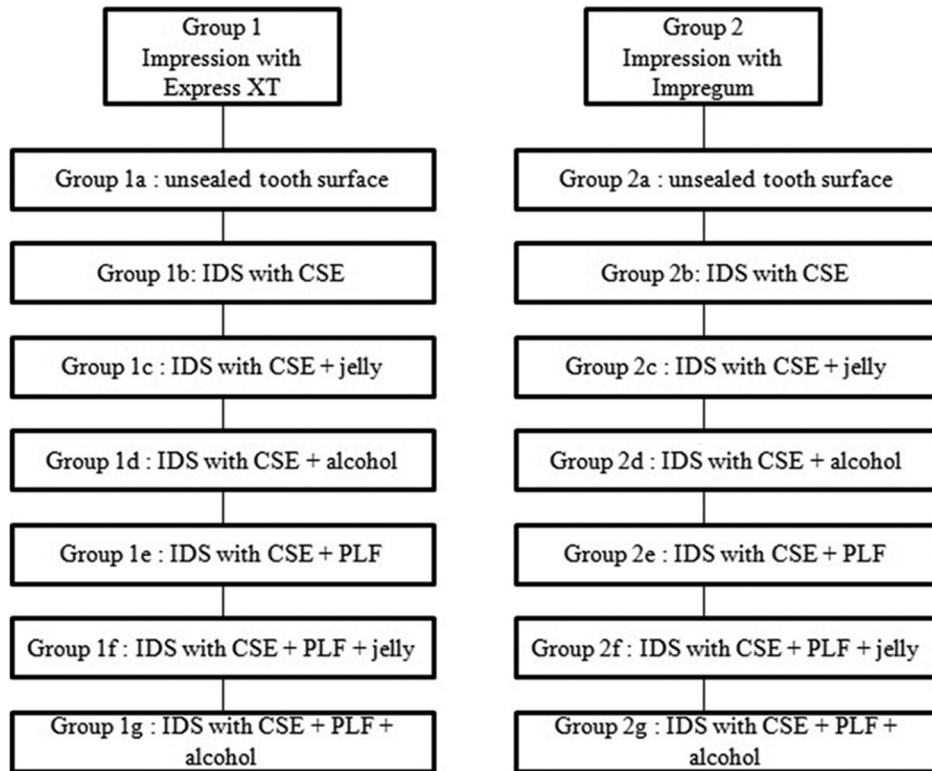


Figure 1: Schematic design of the experimental groups

and gently air dried. SE Bond was then applied, mildly air dried, and light cured for 10 s using a conventional halogen light curing unit

- Group 1c: IDS with CSE and glycerin jelly. The adhesive system was applied as described for Group 1b. The polymerization of the adhesive was followed by the application of an air-blocking barrier with glycerin jelly and was then light cured for an additional 10 s. The glycerin jelly was rinsed under running tap water
- Group 1d: IDS with CSE and alcohol. The adhesive system was applied as described for Group 1b. The surface of the adhesive system was wiped with a cotton pellet soaked in 70% alcohol for 10 s
- Group 1e: IDS with CSE and Protect Liner F (PLF). The adhesive system was applied as described for Group 1b. After application of the adhesive, PLF was placed on the adhesive surface using a brush-on technique and was then light cured for 20 s
- Group 1f: IDS with CSE and PLF + glycerin jelly. Both materials were applied as described for Group 1e. The polymerization of the cured low-viscosity composite resin was followed by the application of an air-blocking barrier with glycerin jelly and light curing for an additional 10 s. The glycerin jelly was rinsed under running tap water

- Group 1 g: IDS with CSE and PLF + alcohol. Both materials were applied as described for Group 1e. The surface of the cured low-viscosity composite resin was wiped with a cotton pellet soaked in 70% alcohol for 10 s.

A monophasic polyether Impregum was used in Group 2, and subgroups similar to Group 1 (2a, 2b, 2c, 2d, 2e, 2f, 2g) were assigned based on the materials and techniques used [Figure 1].

Individual trays with self-cured acrylic resin (JET - Clássico, São Paulo, SP, Brazil) were prepared. The adhesive was applied to the tray and was permitted to dry for 10 min. In Groups 1a to 1g, the putty/wash one-step technique was applied using Express XT. The light-body material was injected over the tooth surface. The tray was filled with the heavy-body material, and then the tray was placed over the tooth. In Groups 2a to 2g, the one-step technique was applied using Impregum. The medium-body material was injected over the tooth and in the tray, and the tray was placed over the tooth. The impression materials were allowed to set for 10 min before being removed from the tooth. Five impressions were taken for each group.

Each tooth surface was photographed using a digital camera Nikon Coolpix P100 (Nikon, Melville, NY, USA) with a TL3 model light source (Olympus, Center Valley, PA, USA). The images were saved in JPEG format and were used to examine the presence of unpolymerized and/or residual impression materials left on the treated tooth surface.

## RESULTS

The interactions between the impression materials and the resin materials are described in Table 2.

In the control groups (Groups 1a and 2a), no interaction was observed between the impression materials and the tooth structure [Figure 2].

For the vinyl polysiloxane impression material, the group that received IDS with the CSE (Group 1b) and the group with PLF (Group 1e) had observable interactions in three and five impressions,

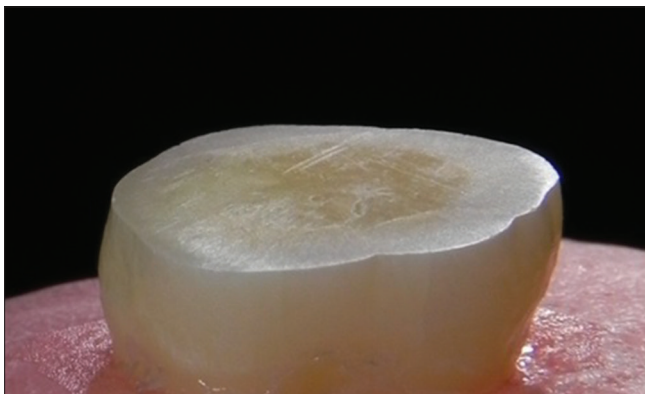
respectively. A small quantity of unpolymerized impression material remained attached to the adhesive system [Figure 3] or to the low-viscosity composite resin. The application of glycerin jelly followed by an additional light cure (Group 1c) and the use of cotton pellet soaked in alcohol (Group 1d) prevented the interaction between the vinyl polysiloxane and the adhesive system [Figure 4]. However, neither treatment was completely effective with the low-viscosity composite resin, as a small quantity of unpolymerized impression material remained attached to the PLF in one impression.

For the polyether impression material, the group that received IDS with CSE (Group 2b) and the group with PLF (Group 2e) had observable interactions in five and three impressions, respectively. A small quantity of polymerized impression material remained attached to the adhesive system or to the low-viscosity composite resin [Figure 5]. The same interaction was observed for the groups that received IDS with CSE

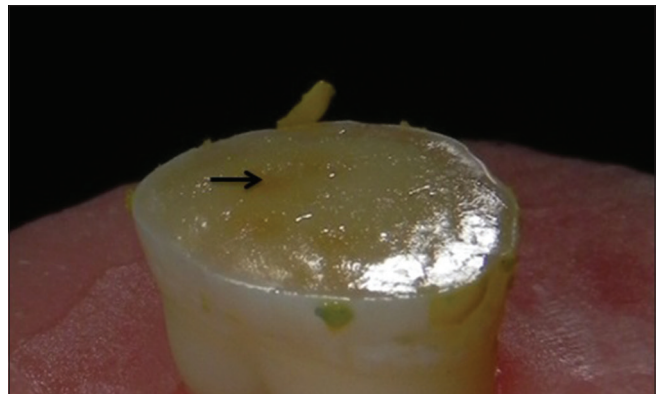
**Table 2: Interactions between the impression materials and the resin materials**

Treatments	Group 1 vinyl polysiloxane (Express XT)	Group 2 polyether (Impregum)
Control (without IDS)	Group 1a-No interactions	Group 2a-No interactions
IDS with CSE	Group 1b-Interaction in three impressions (unpolymerized material attached to the CSE)	Group 2b-Interaction in five impressions (polymerized material attached to the CSE)
IDS with CSE+jelly	Group 1c-No interactions	Group 2c-Interaction in three impressions (polymerized material attached to the CSE)
IDS with CSE+alcohol	Group 1d-No interactions	Group 2d-Interaction in two impressions (polymerized material attached to the CSE)
IDS with CSE+PLF	Group 1e-Interaction in five impressions (unpolymerized material attached to the PLF)	Group 2e-Interaction in three impressions (polymerized material attached to the CSE)
IDS with CSE+PLF+jelly	Group 1f-Interaction in one impression (unpolymerized material attached to the PLF)	Group 2f-No interactions
IDS with CSE+PLF+alcohol	Group 1g-Interaction in one impression (unpolymerized material attached to the PLF)	Group 2g-No interactions

\*Five impressions were obtained for each group. CSE: Clearfil SE Bond, PLF: Protect Liner F, Jelly: Glycerin jelly followed by an additional light cure, Alcohol: Cotton pellet soaked in 70% alcohol, IDS: Immediate dentin sealing

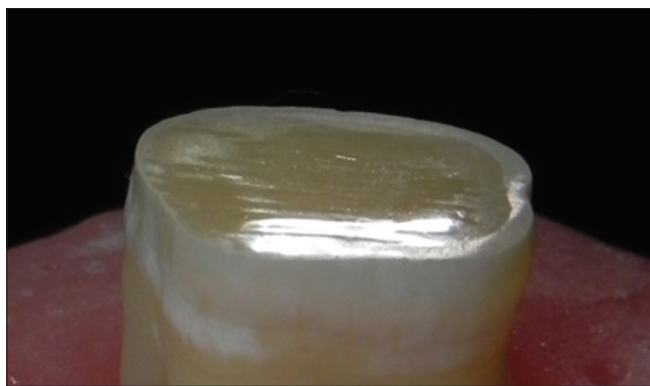


**Figure 2:** Photo of the tooth surface-Control group (without immediate dentin sealing) and impression with vinyl polysiloxane: There is no impression material attached to the dentin surface. The same was observed for polyether



**Figure 3:** Photo of the tooth surface-immediate dentin sealing with Clearfil SE Bond and impression with vinyl polysiloxane: Small areas of unpolymerized impression material (arrow) are attached to the surface of the resin material. The same was observed for Protect Liner F





**Figure 4:** Photo of the tooth surface-immediate dentin sealing with Clearfil SE Bond, alcohol application and impression with vinyl polysiloxane: There is no interaction between the impression material and the resin material. The same was observed for glycerin jelly application, as well as for IDS with Protect Liner F and impression with polyether after glycerin jelly or alcohol application

and the application of glycerin jelly (Group 2c) and a cotton pellet soaked in alcohol (Group 2d), occurring in three and two impressions, respectively. When both treatments were applied to the low-viscosity composite resin (Groups 2f and 2g), no interactions were observed.

## DISCUSSION

The hypothesis of this study was partially rejected, as the prevention of interactions following the proposed treatments depended on the impression material and the resin materials employed.

In the control groups, in which the IDS was not applied, there was no interaction between the impression material and the tooth structure. However, in the groups in which the IDS was applied, there was an observable interaction of vinyl polysiloxane and the polyether with the resin materials, either with the adhesive systems or the low-viscosity composite resin. This finding is related to the presence of the OIL.<sup>[3]</sup> The CSE adhesive system and the PLF low-viscosity composite resin are composed of methacrylates<sup>[14]</sup> and when light cured, these materials present a superficial layer of approximately 40  $\mu\text{m}$  that does not polymerize with air-oxygen contact.<sup>[11,15]</sup> The OIL has a jelly-like consistency and is composed mainly of residual monomers that do not react after the polymerization of the resin material.<sup>[16]</sup> These nonreacting monomers may go on to interact with the impression materials.<sup>[17,18]</sup>

Different interaction types occurred between the resin materials and the impression materials. For the vinyl polysiloxane, unpolymerized impression material



**Figure 5:** Photo of the tooth surface-immediate dentin sealing with Clearfil SE Bond, glycerin jelly application and impression with polyether: Polymerized impression material is attached to the CSE. The same was observed for alcohol application

remained over the resin materials. For the polyether, polymerized impression material remained joined to the resin materials. It is likely that the difference between the chemical composition of the vinyl polysiloxane and the polyether caused the impression materials to react in the different ways to the resin materials.

The permanence of the unpolymerized vinyl polysiloxane over the CSE adhesive system was observed in three impressions and was also observed in every impression with the PLF low-viscosity composite resin. It is speculated that the monomers presented in the OIL may have reacted with the platinum salt, which is the catalyst in the reaction of polymerization of the vinyl polysiloxane,<sup>[19]</sup> and a small portion of the light impression material remained unpolymerized over the resin materials. However, the amount of unpolymerized material is negligible and is likely functionally irrelevant; therefore, it is believed that this interaction does not render the use of the impressions impractical.

For the polyether, the polymerized material remained joined to the resin materials in all the impressions with CSE and in three impressions with PLF. This interaction may have occurred due to the polymerization reaction of the polyether (ionic polymerization), in which the initiator agent of the reaction is an ion (cation) that can react with the free radicals of the monomers from the resin materials on the surface. Moreover, the hydrophilicity, as well as the higher stiffness and the low resistance to the tearing of the polyether when compared to the vinyl polysiloxane, may have favored the superficial adhesion and the tearing of the impression material.<sup>[20]</sup> This type of interaction renders the use of the impressions impractical.

Taking into account the principles of molecular interaction, it is believed that the OIL was critical for the adhesion between the increments of composite resin and with the adhesive system.<sup>[16]</sup> However, currently, it is known that OIL is not essential for the chemical adhesion of the layers of the composite resin.<sup>[16,21]</sup>

Additional polymerization with glycerin jelly over the layer of resin material,<sup>[12]</sup> as well as the use of alcohol,<sup>[22,23]</sup> is aimed at reducing or eliminating the OIL. Both procedures were effective when applied over the CSE adhesive system and the impression was made with vinyl polysiloxane, as no interaction was observed between the adhesive and impression material. However, it is speculated that there is a certain amount of residual unpolymerized monomers on the surface of the adhesive after the application of glycerin jelly or alcohol because the polyether remained joined to the adhesive surface, subsequently tearing and rendering the impression unusable. These findings agree with the results of a study by Magne and Nielsen.<sup>[24]</sup>

Protect Liner F has a higher percentage of filler than CSE and consequently, should present fewer residual monomers after the light curing. Therefore, the application of glycerin jelly and alcohol were effective in preventing interactions with PLF when the polyether was used, as there was no interaction of this impression material with the low-viscosity composite resin. The application of glycerin jelly and alcohol on the low-viscosity composite resin was effective in four impressions with vinyl polysiloxane, and an interaction was observed only in one impression. The interaction was characterized by incomplete polymerization and the permanence of unpolymerized impression material adhering to the surface of the PLF. However, the amount of unpolymerized material was insignificant, and therefore the resulting impressions remain usable. Despite using standardized procedures, small variations, such as the final thickness of the low-viscosity composite resin, the thickness of the glycerin jelly applied on the low-viscosity composite resin, and the application pressure of the cotton pellet soaked in alcohol, likely contributed to the lack of effectiveness when removing or eliminating the OIL in the sample in which the interaction was observed.

Both the application of glycerin jelly and alcohol affected the OIL, as the results were similar for the same impression material when comparing the two

techniques. This result indicates that professional discretion must be used when selecting a technique.

This *in vitro* study presents some limitations, such as the shape of the samples. The application of IDS was evaluated using flat dental surfaces. However, the preparations for indirect restorations are geometric and irregular, making it difficult to apply resin materials and remove OIL. Thus, additional studies are necessary to determine the nature of the interactions between the resin materials and the impression materials and to solve this potential clinical problem.

## CONCLUSIONS

Despite the limitations of this *in vitro* study, the following conclusions can be drawn:

- The IDS using the CSE adhesive system or the PLF low-viscosity composite resin produces interactions with the Express XT vinyl polysiloxane and with the Impregum polyether
- The application of glycerin jelly and alcohol prevented the interactions between the CSE and the Express XT and between the PLF and the Impregum. However, these treatments were not completely effective in preventing the interactions of CSE with the Impregum or the interactions of the PLF with the Express XT.

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