"Laboratory Characterization of a Glass Ionomer Base/liner Material"

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I. Introduction

Esthetic restorative materials often fail prematurely due to marginal staining or recurrent caries. Such behavior may be linked to a deterioration at the interface between the restorative material and the remaining tooth structure. Presenting as marginal caries or staining, restorations may need to be replaced within a couple of years of clinical service. The development of dentin bonding agents, glass ionomer formulations, and new adhesive clinical techniques have been focused at overcoming these deficiencies and propose to improve the clinical longevity of esthetic restorative materials.

The use of a glass ionomer cement as a base or liner beneath a composite resin restoration, referred to as the "sandwich" or "laminate" technique, has recently been identified as the most reliable esthetic adhesive procedure. The concept behind this restoration is based upon the predictable adhesion of glass ionomer cements matched with the esthetics and durability of the composite resin. Furthermore, the potential benefits from a continued fluoride release may be of significance in reducing the incidence of recurrent caries or may assist with the treatment of high risk caries individuals.

Research into the use of liners has been limited to mostly laboratory studies involving microleakage behavior and adhesive bond strengths to either the dentin or composite resin. Recently, Watson has shown the utility of imaging a glass ionomer liner using scanning confocal microscopy. Question was raised relative to the adaptation of a new light cured glass ionomer which was found to pull away from the underling dentin. Such an examination with the confocal microscope has allowed for non-destructive imaging (in situ) that may provide a better understanding of the behavior of these new materials. Without the introduction of preparation artifacts, greater confidence is gained with observed research results. Further, using specific fluorescence labels, an understanding of the adhesive mechanisms may be possible. Such knowledge will ultimately lead to a better understanding of current formulations and provide insights towards developing new and more efficacious formulations.

II. Study Objectives

The purpose of this laboratory study was to evaluate the behavior of a light cured glass base/liner material, Ionosit (DMG, Hamburg) when used
with a composite resin. Specifically, an understanding of the adhesive qualities and microbiological properties were examined:

**Specific Aim 1:** Image the glass ionomer/dentin interface of Ionosit utilizing laser confocal microscopy.  
**Specific Aim 2:** Measure the ability of Ionosit to inhibit the growth of Mutans streptococcus in cell culture tests.

### III. Experimental Design

**A. Material Selection.** The light cured glass ionomer Ionosit Base/liner (DMG, Hamburg) was be used with a hybrid type direct composite resin (Universal Hybrid, DMG, Hamburg) restorative material. An accepted liner material, Vitrebond (3M Dental, St. Paul, MN) was used as a control material.

**B. Confocal Microscopy Phase**

**Tooth Preparation:** Recently extracted third molar human teeth were prepared with Class V type cavities for composite resin on the facial and lingual surfaces. No. 556 plain tungsten carbide burs in a high speed handpiece equipped with an air/water spray were used to cut the preparations. New burs were frequently employed. The preparations were made as uniform as possible with the pulpal floor placed at a depth of 4 mm, as measured in the central part of the tooth. The preparations were approximately 8 mm wide (mesial-distal) by 4 mm in width (buccolingual). The preparations were washed with a water spray for 10 seconds and dried with oil free compressed air. A total of 20 preparations were made with all margins in enamel.

**Restoration Placement:** The prepared teeth were restored with the so called "laminate" or "sandwich" placement technique. The incremental technique for composite placement was used as well. Finishing of the restorations was accomplished with the excess material removed with carbide burs. The final finishing of the restorations was accomplished using fine grit composite finishing diamonds followed by alumina polishing pastes.

**Scanning Confocal Microscopy:**

To facilitate fluorescence imaging with the scanning confocal microscope, a label was placed into the glass ionomer liners prior to
placement in the prepared teeth. An initial saturation of hydroxyethyl methacrylate (HEMA) was accomplished by slow titration of rhodamine B isothiocyanate using an ultrasonic bath. When a visible precipitate was observed, the solution was centrifuged and the supernatant drawn off for incorporation into the glass ionomers. With the Vitrebond material, the liquid portion was labeled with the rhodamine B at a ratio of 0.1 ml label to 6 ml glass ionomer liquid. With the Ionosit material, a ratio of 0.1 ml of label was incorporated into 2 grams of glass ionomer liner.

SCM samples were prepared by sectioning through the restorations using a low speed diamond saw (Buehler, Inc., Houston, TX) with water coolant (Figure 1.). The sections were then polished on a Buehler Ecomet rotary polisher with 600 grit aluminum oxide, 9um diamond paste, and 3um diamond paste and ultrasonically cleaned in distilled water between each step. The SCM evaluation utilizes in situ specimens and was based upon the methods described by Watson7. The samples were stored in an aqueous solution of SlowFade™ (Molecular Probes, Inc., Eugene, OR) under refrigeration until imaged. Many of the computerized features of the laser scanning microscope (Zeiss LSM - 10) were utilized in imaging the specimens and storage of the image was in a digital format on floppy disk. Viewing and manipulation of the images for presentation were accomplished on a Macintosh based system utilizing the NIH Image 1.52a software package. Adaptation of the liners to the dentin surfaced was assessed along pulpal and axial walls.

D. Microbiology Phase

The Ionosit Base/liner (DMG, Hamburg) and Vitrebond liner (3M Dental, St. Paul, MN) were compared for their ability to inhibit the growth of Streptococcus mutans. An antibiotic control disc was utilized to validate the inhibitory activities. A composite resin was used as a negative control. Agar plates were prepared by placing 20 ml of tryptic soy agar into sterile petri dishes. Specimens of the glass ionomer materials 6 mm in diameter were prepared and stored in sterile saline at 37 degrees C for 24 hours and 7 days.

The agar plates were inoculated with standardized colonies of Streptococcus mutans #6715. Immediately after inoculating the plates, the materials were place on the agar surfaces using sterile procedures. A total
of 10 plates were prepared. Five plates were used for examination of specimens aged for 24 hours and 5 plates were used for specimens aged 7 days. The plates will be incubated overnight at 37 degrees C. Inhibition zones were directly measured on the plates using a dial caliper (see Figure 7.).

IV. Results

Results of the laser scanning confocal microscopy found the Ionosit liner to produce a close adaptation to the dentin surface with no evidence of gap formation between the liner and dentin. In contrast, gaps were observed during imaging of the Vitrebond liner specimens. These gaps were observed mostly on the pulpal floors of the Class V cavities.

A consistent finding with the Ionosit liner specimens was the development of an apparent amorphous "reaction zone" between the original liner and the dentin. This zone was distinct from the labeled glass ionomer and the dentin surface. Representative pulpal and axial confocal images are shown in Figures 2. through Figures 6.

Results of the microbiology testing are shown in Table 1. As can be seen, there was greater inhibition of growth for both liners at 24 hours compared to 7 days. There were no statistical differences between the mean inhibition zones for the two materials.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mean Zone of Inhibition (mm)</th>
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<tbody>
<tr>
<td></td>
<td>24 Hours</td>
</tr>
<tr>
<td>Positive control</td>
<td>10.2</td>
</tr>
<tr>
<td>Negative control</td>
<td>0</td>
</tr>
<tr>
<td>Ionosit Liner</td>
<td>8.6</td>
</tr>
<tr>
<td>Vitrebond</td>
<td>9.1</td>
</tr>
</tbody>
</table>

Table 1.

V. Discussion and Conclusions

The adaptation to dentin cavities and antimicrobial behavior of a new glass ionomer liner was examined in vitro. Laser scanning confocal microscopy and standard agar overlay techniques were used. The confocal
images clearly demonstrate excellent adaptation to the dentin surfaces. This adaptation appears to be the result of a continued reaction of the new liner beyond the initial light polymerization. The amorphous layer observed between the labeled liner and the dentin was void of rhodomine B and must have developed subsequent to liner polymerization. The manufacturer suggests that the single component Ionosit contains anhydrous acrylic acid that becomes hydrated from moisture in the dentin. This would suggest that a "dark" reaction of the glass ionomer continues beyond the initial placement and would explain the unlabeled amorphous zone found on pulpal and axial walls. This "fill in" of a glass ionomer phase would facilitate the polymerization shrinkage that accompanies resin reinforced glass ionomer cements.

The microbiologic behavior of the Ionosit liner compares favorably with the Vitrebond liner that has previously demonstrated inhibition to plaque producing organisms. The decrease in mean zone over time has not been reported previously. This is most likely the result of less fluoride and other ions leaching out as a function of specimen age.

Final validation of the clinical consequences of this new technology will require clinical trials. However, initial laboratory results offer sound evidence for the use of Ionosit liner under composite resin restorations. The further advantage of a single component void of a mixing step is an obvious clinical advantage over other commercial glass ionomer liners.

VI. Literature Cited


Figure 1. Specimen preparation for Laser Confocal Imaging.
Figure 2. Interface at pulpal floor.
Figure 3. Interface along axial wall.
Figure 4. Interface along axial wall.
Figure 5. Interface at pulpal floor.
Figure 6. Interface along axial wall.
Figure 7. Agar plating for antimicrobial tests.