Comparison of the effect of insertion techniques of a resin composite on dentinal adaptation of two visible light-cured bases: Direct evaluation versus a replica technique

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Abstract
This scanning electron microscopic study evaluated the adaptation of two visible light-cured bases, Calciomol LC and Ionoseal, to the dentinal surface after the use of various techniques to insert the resin composite material. Twenty-eight Class I cavities were prepared and restored in four groups: seven Calciomol LC and resin composite placed with a bulk or an incremental technique; and Ionoseal and resin composite placed with a bulk or an incremental technique. The specimens were sectioned longitudinally through the center of the restoration and an impression was made with a poly(vinyl siloxane) impression material. When the tooth surfaces and the impressions made from these surfaces were compared in the scanning electron microscope, extra gaps on tooth surfaces were observed that were not apparent in the impressions. These extra gaps probably resulted from desiccation of tissues; thus, the observation of replicas was useful to eliminate the inclusion of “false” gaps in the analysis. The results indicated that there was no substantial difference between Calciomol LC and Ionoseal base materials placed under resin composite inserted with an incremental technique. (Quintessence Int 1996;27:63-68.)

Clinical relevance
These results show that the use of an incremental technique with visible light-cured calcium hydroxide adapted better to dentin of primary teeth. In these SEM studies of gap formation between two materials, the combination of direct examination with replica technique will give more accurate results than will direct examination alone.

Introduction
Restorations often require an intermediary base of lining material to alleviate postoperative hypersensitivity and to provide protection of the pulp. However, the properties of each specific lining material confer advantages and disadvantages.

Both calcium hydroxide and glass-ionomer cement have become lining materials of choice: calcium hydroxide because of its ease of handling and its excellent pulpal response, and glass-ionomer cement because of its ability to adhere to tooth structure, its potential to be etched and reliably bonded, and its apparent ability to reduce postoperative sensitivity when used as a base under posterior resin composites.

Prisma visible light-cured (VLC) Dycal has been shown to have significant improvements in several physical properties. This material consists of a dispersion of calcium hydroxide and barium sulfate in a urethane dimethacrylate resin and is activated by visible light. Several advantages attend this formulation, not the least of which is its chemical bond with resin restorative materials.

Research and development efforts for glass-ionomer cements are currently directed toward eliminating the disadvantages of working and setting tie by incorporating light-curing technology, while preserving the...
Table I

Restorative treatments for 28 Class I cavity preparations

<table>
<thead>
<tr>
<th>No. of teeth</th>
<th>Base</th>
<th>Etching time</th>
<th>Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Calcimol LC</td>
<td>60 s (enamel)</td>
<td>Clearfil (incremental technique)</td>
</tr>
<tr>
<td>7</td>
<td>Calcimol LC</td>
<td>60 s (enamel)</td>
<td>Clearfil (bulk technique)</td>
</tr>
<tr>
<td>7</td>
<td>Ionoseal</td>
<td>60 s (enamel)</td>
<td>Clearfil (incremental technique)</td>
</tr>
<tr>
<td>7</td>
<td>Ionoseal</td>
<td>20 s (glass-ionomer base)</td>
<td>Clearfil (bulk technique)</td>
</tr>
</tbody>
</table>

important benefits of fluoride release and dentinal bonding. As filled polymers, light-cured lining materials may undergo volumetric change during polymerization. Such dimensional changes have been reported to have an effect on the adaptation of resin and its relationship with the tissue to which it is applied.

Recent studies have shown that gaps of different size and number may occur between VLC lining materials and tissue. The size and number of the gaps depend on the type of restoration, the technique of placement, and the methods of sectioning and examination.

The method used in the present study was developed by Gwinnett, who reported that poly(vinyl siloxane) impression materials can accurately reproduce the relationship between restoration and tissue.

The purpose of this study was to examine the adaptation of a visible light-cured calcium hydroxide (Calcimol LC, VOCO) and a resin-modified (visible light-cured) glass-ionomer cement (Ionoseal, VOCO) to dentinal surfaces prepared with high-speed diamond burs and the effects of various resin composite insertion techniques in vitro. The study was also designed to determine whether gaps observed with VLC calcium hydroxide and VLC glass-ionomer cement were real or artifacts of the impression technique.

Method and materials

A total of 28 Class I cavities were prepared on the occlusal surface of freshly extracted maxillary and mandibular primary molars. The cavities were cut with a No. 56 tungsten carbide bur in a high-speed turbine and with abundant air-water spray. All cavities were prepared by the same operator to a depth of 0.5 mm below the dentinoenamel junction. The teeth were restored as described in Table I.

The placement of Calcimol LC was carried out by the same operator for 14 teeth. When Calcimol LC was placed on the pulpal floor, it tended to form a meniscus curve and leave an apparent deficiency on the pulpal floor, as reported by McConnell et al. Therefore, a second layer of Calcimol LC was placed. Each layer was cured for 20 seconds, according to the manufacturer's directions. The cavosurface enamel was then etched. An etching gel containing 37% phosphoric acid was applied for 60 seconds. This was followed by 30-second washing and 30-second drying processes.

Ionoseal was placed by the same operator in another group of 14 cavities and was cured for 20 seconds. The cavosurface enamel was etched with the same acid gel for 60 seconds. However, the Ionoseal material was only etched for 20 seconds and then washed for 30 seconds and dried for 30 seconds.

The dentinal bonding material was applied with a sable hairbrush, as recommended by the manufacturer, and the excess material was removed with an air syringe. The resin composite restorative material (Clearfil, Kuraray) was placed either in bulk (one increment) or in a two-occlusal incremental technique. Each increment was cured for 20 seconds. All specimens were embedded in acrylic resin.

The specimens were stored in 37°C distilled water for 24 hours. Following the storage period, the specimens were sectioned longitudinally through the center of the restoration with a diamond blade (Isomet, Buehler). The specimens were treated for 10 seconds with 37% phosphoric acid to remove the
smear layer that resulted from the sectioning procedure. They were thoroughly rinsed with water for 20 seconds and were dried carefully with air spray.

Impressions, for which the teeth were dried briefly to minimize desiccation, were taken one at a time. Permagum (ESPE) light-bodied poly(vinyl siloxane) impression material was mixed and applied to the cut tooth surface. A flat toothpick was used to tamp the fluid material into the region of the restoration. After it had set, the impression was removed, trimmed, and mounted on an aluminum stub. Both the impressions and the sectioned tooth surface were dried with high-vacuum SEM until no moisture remained. Completion was indicated by a lamp, which turned off when the drying procedure was completed sufficiently. All the specimens were coated with gold-palladium and examined with a scanning electron microscope (SEM) (Jeol JSM 5400). The SEM observations were recorded on film.

Results
The relationship between liner and dentin was accurately reproduced by the impression material (Fig 1). When gaps were present, the material penetrated into them to produce a thin flash or wall, characterizing the site, width, and extent of the gaps.

When two coats of VLC Calcimol were placed on the pulpal floor, the material tended to pool into internal line angles. As the width of the lining material at the central region increased, the meniscus effect was reduced (Fig 2).

In the group in which Calcimol LC was used and the restorative material was placed with an incremental technique, both the sectioned tooth surface and impressions revealed good adaptation between the tooth and calcium hydroxide at the cavity floor (Figs 3a and 3b). In some areas, discontinuous gaps in the range of 5 μm wide were observed on tooth surfaces and impressions. Both showed areas along the axial wall with a few discontinuous gaps (of less than 5 μm).

In the group in which Ionoseal was used and the restorative resin material was placed with a bulk technique, tooth surfaces and impressions revealed several continuous or discontinuous gaps approximately 5 to 10 μm wide at the cavity floor (Fig 4). Also, several discontinuous gaps of less than 5 μm were noted on the axial walls.

In the group in which Ionoseal was used under the restorative resin placed with a bulk technique, some impressions revealed a good adaptation at the cavity floor and discontinuous gaps (approximately 5 μm...
Fig 3a The adaptation between VLC Calcimol and the dentinal floor of the preparation.

Fig 3b Impression of the same area.

Fig 4 A gap is evident between the cavity floor and VLC Calcimol (left). Impression of the same area (right).

Fig 5a No gap formation is evident between the axial wall and Ionoseal.

Fig 5b On the replicated surface, adaptation of Ionoseal to the dentinal surface is shown to be good in the same area.

Wide), while some tooth surfaces revealed fracture lines along the cavity floor and continuous gaps of more than 10 μm wide (Figs 7a and 7b). In all groups, the observation of some tooth sections revealed fracture lines lying along the proximal walls and the floor of the cavity. The impression surfaces of these tooth sections did not reveal these fracture lines (Figs 8a and 8b). In addition, fewer gaps were apparent on the impression surfaces than on the tooth surfaces.

Discussion

The results of this study indicated that the most reliable adaptation of the resin composite restoration to the cavity walls was obtained when the resin was incrementally inserted and resin-modified glass-ionomer
A small, discontinuous gap (arrow) is present between the axial wall and lonoideal.

In the impression, a small, discontinuous gap (arrow) is evident between lonoideal and the axial wall in the same area.

A contraction gap of greater than 10 μm is present between lonoideal and the dentinal floor of the preparation.

Impression of the same area.

An extra gap is present on the tooth surface (arrow) but does not exist in the impression of that surface (Fig 8b).

The second gap is not evident in the impression.
cement or VLC calcium hydroxide was used as base material. The insertion technique of the restorative material appears to have a direct influence on the dentinal adaptation of VLC lining material.\textsuperscript{1,1,12}

These materials are placed on the cavity floor as a resin base, allowing them to make a chemical bond with the overlying resin composite restorative material.\textsuperscript{6,8,9,13,14} Any polymerization shrinkage occurring in this overlying restorative material could pull the lining material off the cavity floor and walls.\textsuperscript{4} It has been shown that the maximal shrinkage occurs when the bulk insertion technique is used. The results of this study supported the suggestion that resin composites should be placed with an incremental technique.

McConnell et al\textsuperscript{11} reported that VLC calcium hydroxide lining material tends to form a meniscus curve and leave an apparent deficiency on the pulpal floor, resulting in a thin central film of liner on the floor of the preparation. They suggested placement of a second layer of liner if a deficiency occurs, but did not indicate the number of specimens used in their study. On the other hand, a tight junction between VLC calcium hydroxide and dentin can be obtained if two coats are applied as recommended by Gwinnett et al.\textsuperscript{10} Therefore, in the present study, a second layer of VLC calcium hydroxide was placed in all of the specimens.

McConnell et al\textsuperscript{11} also compared different base materials with different restorative materials and techniques. They used poly(vinyl siloxane) impressions to observe the adaptation of only a glass-ionomer cement to tooth. Their observations of the other groups (VLC Dycal) were made directly on the tooth surfaces. They reported that they observed good adaptation in the specimens in which resin composite was placed on the glass-ionomer cement base, regardless of whether the bulk or incremental technique was used. When VLC Dycal was used as liner, they observed 10 \( \mu \)m-wide gaps. The authors emphasized that their results required confirmation.\textsuperscript{4}

Gwinnett et al\textsuperscript{10} reported that gaps probably are created as a result of tissue desiccation and the accompanying volumetric change occurs in the preparation of tissue specimens for scanning electron microscopy. In the present study, both tooth surfaces and poly(vinyl siloxane) impression material surfaces were observed in SEM. The results were found to be in agreement with the findings of Gwinnett et al.\textsuperscript{10}

In some tooth sections, the observed gaps were significant; however, the impressions made from the same tooth sections revealed no gaps. This finding demonstrates the usefulness of the impression technique in eliminating false conclusions generated by the shrinkage that results from tissue desiccation.

**Summary**

This present study revealed no substantial differences in dentinal adaptation between calcium hydroxide or glass-ionomer cement base materials when resin composite was placed over them in an incremental technique. Gaps may be exaggerated when the tooth surface is evaluated directly by SEM; the replica technique seems to give more accurate results.

**References**