Scanning Electron Microscopic Evaluation of Composite Resin-Dentin, Calcium Hydroxide-Dentin and Resin- Calcium Hydroxide Interfacial Gap with Composite Resin Restorations- An in vitro Study

Manoranjan Reddy, *Vanka Amit, **SSV Prasad
Department of Conservative Dentistry and Endodontics, **Department of Periodontics, Aditya Dental College & Hospital, Beed (Maharastra), *Department of Pedodontics and Preventive Dentistry, People’s Dental Academy, Bhanpur, Bhopal (MP)

Abstract:
The dental pulp has been shown to have its own reparative capacity and is capable not only of healing but also of providing a dentinal bridge in the absence of calcium hydroxide. The present study was performed to evaluate interfacial gaps formed due to polymerization shrinkage of composite resin. 20 Maxillary or Mandibular, freshly extracted human third molars were prepared and filled using composite with a calcium hydroxide base. The samples were divided into two groups based on primer/bonding agent used i.e. Scotchbond multipurpose (Group I) and Single bond (Group II). Sectioned samples were gold sputtered and analyzed using Scanning Electron Microscope (SEM). The interfacial gap in specimens belonging to group I and II was observed at the 3 interfaces viz; Calcium hydroxide-dentin interface (A), Composite resin - calcium hydroxide interface (B) and Composite resin - dentin interface (C). The interfacial gap formed between calcium hydroxide and dentin (A) was highly significant (p <0.01) in both groups i.e. Group I and Group II, when it was compared with ‘B’ and ‘C’ of the same group. There was no statistical significant difference between group ‘B’ and ‘C’. Thus in both the groups an interfacial gap was found between the calcium hydroxide and dentin. Interposition of calcium hydroxide between tooth and resin possesses some clinical disadvantages and is recommended in selective clinical situations.

Key Words: SEM, Calcium Hydroxide base, Interfacial gap, Composite resin.

Introduction:
Quality and durability of the marginal seal is a major consideration in the selection of a restorative material. Investigators have used composite resin and observed a pulpal reaction that is similar to that obtained when silicate cements are used. It was, therefore considered necessary to protect the pulp dentin organ with liner materials based on calcium hydroxide, thus isolating the dentin from the irritant action of resins (Pashley et al, 1990). These liners provide protection to the pulp-dentin complex by covering the smear plugs and sealing the dentinal tubules against chemical irritants and bacterial invasion (Stanley et al, 1969).

Studies have also demonstrated that dental materials such as silicate cement, zinc phosphate cement, composite resin and amalgam are biologically compatible, even if applied directly to the exposed dental pulp, provided that the latter is hermetically sealed and protected from any subsequent bacterial leakage. Moreover, the dental pulp has been shown to have its own reparative capacity (Cox, 1987), capable not only of healing but also of providing a dentinal bridge in the absence of calcium hydroxide (Kanka, 1990).

The aims of the present scanning electron microscopic study was to evaluate interfacial gaps formed due to polymerization shrinkage of composite resin at
A. The interface between the calcium hydroxide and untreated dentin.
B. The interface between composite resin and calcium hydroxide.
C. The interface between the composite resin and the treated dentinal surface.

Materials and Methods:
a) Sample Selection : 20 Maxillary or Mandibular, freshly extracted human third molars were used as samples for this study (Fig. 1 a). The inclusion criteria comprised of vital maxillary or mandibular molars, which were of similar shape and size. The teeth, which were carious, fractured, or had undergone any regressive alterations like abrasion, attrition or erosion were excluded from the samples. Selected teeth were cleaned free of debris and fixed in 10% neutralized formalin solution before subjecting to further treatment.

b) Methodology: Exactly 2 mm deep heels were made on the buccal surfaces at the center of cemento-enamel
junction of each tooth by measuring the depth of heels with Williams graduated periodontal probe. The buccal surface of each tooth was then ground flat with a water cooled orthodontic cast trimmer until the heels disappeared. (Fig. I b)

A self-hardening calcium hydroxide, catalyst and base (Dycal) was mixed on a paper pad with spatula and a thin layer of 4 x 2 dimension was applied over the exposed dentinal buccal surface, adjacent to the area of pulp chamber (Fig. I c). After the calcium hydroxide was allowed to set, these specimens were divided into the two groups having ten teeth in each group.

**Group I (Scotch Bond Multipurpose):**

The remaining exposed enamel and dentinal surfaces, which were not covered by calcium hydroxide were etched with scotch bond multipurpose etchant gel for 15 seconds. Etchant was rinsed for 10 to 15 seconds with a water spray. The etched surfaces were dried for 5 seconds by a gentle blow of dry air. Scotch bond multipurpose primer was applied over the calcium hydroxide and etched dentinal surfaces with the help of sable brush and gently dried for 5 seconds with dry air until the shiny surface was established. The scotch bond multipurpose adhesive (bonding agent) was then applied to primed calcium hydroxide and dentinal surfaces with the help of sable brush and light cured for 10 seconds. Hybrid composite resin (Z 100, 3M, ESPE) was applied over the entire dentinal surface including calcium hydroxide until the original buccolingual width (2mm) was obtained and was light cured for 40 seconds (Fig. II a).

**Group II (Single Bond):**

In this group remaining exposed enamel and dentinal surfaces were etched with 37% phosphoric acid gel for 15 seconds. The etchant was rinsed for 10 seconds with a water spray with the help of two way (air water) syringe. Then the etched surfaces were dried for 5 seconds by gentle blow of dry air by leaving the surface moist. Using fully saturated brush tip, two coats of single bond primer/adhesive were applied over the etched surface including calcium hydroxide and light cured for 10 seconds. Then 2mm thick layer of hybrid (Z 100, 3M, ESPE) composite resin was applied over the entire dentinal surface including calcium hydroxide and light cured for 40 seconds. The 2mm thickness was standardized as in group I.

The specimens of both the groups were mounted vertically by half embedding of the root portions in plaster of paris. The teeth were then sectioned with a diamond disc along the longitudinal axis, thus passing through the center of the restoration (Fig. II b) Sectioned surfaces were cleaned with 10% orthophosphoric acid for 3 to 5 seconds and quickly rinsed with air water spray for 15 seconds to remove smear layer. Later all the specimens were dehydrated...
People’s Journal of Scientific Research

Vol. 4(2), July 2011

by increasing concentrations of ethyl alcohol (30%, 50%, 70%, 90% and 100%). Once the specimens were dehydrated with various concentrations of alcohol, they were mounted with silver paste on metallic stubs and gold coated with a sputtering system under vacuum desiccation (Fig. II c) and then examined under scanning electron microscope at an acceleration voltage of 7 to 10 KV.

The interfacial gaps between the calcium hydroxide and unetched dentinal surface (A), composite resin-calcium hydroxide (B) and composite resin-etched dentin (C) were observed under scanning electron microscope. Representative photomicrographs were taken at a magnification of x 100, x 350 and x 3000. The interfacial gaps at three different levels were measured in each photomicrograph and the mean was taken. The values were first obtained in mm and were then converted into micron. Intergroup and Intragroup comparison of interfacial gaps were made by using one way ANOVA and individual group comparison was assessed by Newman - Keul’s studentized range test.

Results:
The amount of interfacial gap in specimens belonging to group I and II was observed at the following 3 interfaces

A. Calcium hydroxide - dentin interface (Fig. III a & III b).
B. Composite resin - calcium hydroxide interface (Fig. III a & III b).

Scanning Electron Microscopic Evaluation of Composite Resin-Dentin ---- M Reddy, V Amit & SS V Prasad
C. Composite resin-dentin interface (Fig. IV a & IVb).

The amount of interfacial gap formed between calcium hydroxide and dentin was highly significant \((p <0.01)\) in both groups i.e. group I and group II, when compared with (B) and (C) of same group. There was no statistical significant difference between ‘B’ and ‘C’ (Table I & II).

The Snedecor’s ‘F’ test also showed that there was no statistical significant difference with all three interfacial gaps between the group I and group II (Table III).

Table I: Comparison of interfacial gaps in scotch bond multipurpose adhesive (Group I)

<table>
<thead>
<tr>
<th>Interfaces</th>
<th>No. of Specimens</th>
<th>Interfacial gap (μm)</th>
<th>Difference Mean ± SD</th>
<th>Comparison Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Calcium hydroxide dentin interface</td>
<td>10</td>
<td>12.6-42.9</td>
<td>26.1 8.45</td>
<td>A-B p&lt;0.01</td>
</tr>
<tr>
<td>B. Composite resin calcium hydroxide interface</td>
<td>10</td>
<td>0-17.6 4.6</td>
<td>6.71</td>
<td>A-C p&lt;0.01</td>
</tr>
<tr>
<td>C. Composite resin-dentin interface</td>
<td>10</td>
<td>0-16.0 4.1</td>
<td>6.35</td>
<td>B-C NS</td>
</tr>
</tbody>
</table>

Table II: Comparison Of Interfacial Gaps In Single Bond Adhesive (Group II).

<table>
<thead>
<tr>
<th>Interfaces</th>
<th>No. of Specimens</th>
<th>Interfacial gap (μm)</th>
<th>Difference Mean ± SD</th>
<th>Comparison Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Calcium hydroxide dentin interface</td>
<td>10</td>
<td>11.8-48.2</td>
<td>26.2 13.60</td>
<td>A-B p&lt;0.01</td>
</tr>
<tr>
<td>B. Composite resin calcium hydroxide interface</td>
<td>10</td>
<td>0-11.1 2.7</td>
<td>4.58</td>
<td>A-C p&lt;0.01</td>
</tr>
<tr>
<td>C. Composite resin-dentin interface</td>
<td>10</td>
<td>0-13.0 1.8</td>
<td>4.24</td>
<td>B-C NS</td>
</tr>
</tbody>
</table>

Discussion

During sample preparation the buccal surface was taken as dentin bonding site. This was done to get a consistent superficial dentin and on flat surfaces tensile stresses can be more producible. On flat dentin surface, the bond strength could withstand the contraction forces. This configuration allowed a large, free and unbonded surface, which permitted the flow of the resin across the free surface during its polymerization shrinkage, thereby minimizing stresses at the bonded surface as suggested by Davidson & de Gee (1984). In this study (Z 100, 3M, ESPE) hybrid composite resin was used because photo polymerizing hybrid composite resins develop higher polymerization shrinkage stresses than micro filled composite resins (Feilzer et al, 1990).

After the conditioning procedure, the buccal surfaces of both groups were kept moist. In the presence of moisture, primer (or) primer/adhesive, can more readily wet the dentin surface and penetrate in to the tubules and demineralized dentin. A collapse of the collagen structure is thus prevented. Kanaka (1992) reported that this might account for the rapid development of a resin impregnated layer over the entire internal dentin area that is able to resist polymerization shrinkage forces originating from the curing of the composite.

Scotch bond multipurpose consists of hydroxy ethyl methacrylate (HEMA), polyalkenoic acid co-polymer, water and bis-phenyl glycidal methacrylate where as Single bond consists of hydroxy ethyl methacrylate, polyalkenoic acid co-polymer, water and bis-phenyl glycidal methacrylate, ethanol. Acetone and alcohol effectively displace water and therefore, are better facilitators of resin primer infiltration in to the collagen network compared to water based adhesive systems (Kanaka, 1992).

In the present study, the amount of interfacial gap found between the calcium hydroxide and dentin in Scotch bond multipurpose as well as Single bond treated composite resin was same. Using SEM, Goracci & Mori (1996) found that the gaps were mainly due to the polymerization shrinkage of the...
composite, which caused the detachment of the calcium hydroxide from the dentinal surface. Reinhardt & Chalkey (1983) reported that calcium hydroxide does not adhere to the smear layer or to the dentinal tubule complex. Due to poor adhesion of calcium hydroxide to the dentinal surface, the polymerization shrinkage of the composite resin caused detachment of the calcium hydroxide, leading to the formation of an interfacial gap. This observation is in agreement with other clinical studies (Ben-Amar et al, 1991; Gwinnett, 1988; Chan and Swift, 1989; McConnell, 1986).

Branstrom et al (1991) reported that such an interfacial gap will be quickly colonized by pulpal fluids and because of inward and outward fluid movement, most of the calcium hydroxide material paste will disappear with time. This observation is in agreement with other clinical studies (Barnes & Kidd, 1979).

Inter group comparison between Scotch bond multipurpose group and single bond group (Table III) showed no significant difference in the amount of gap formed between calcium hydroxide and dentin (A). No significant difference between composite resin-calcium hydroxide interface (B) and composite resin-dentin interface.

The interface between the calcium hydroxide and composite in both the groups showed a gap free attachment. Ben-Amar et al (1991) explained this by the occurrence of a chemical reaction or by mutual dissolution of the components at the Interface.

Composite resin-dentin, interface in Scotch bond multipurpose and Single bond group showed a gap free attachment at x 100 magnification and hybrid layer and resin tag penetration at x 3000 magnification. This result is consistent with other clinical studies (Goracci et al, 1994, Marcos et al, 1997).

This in vitro study showed a significant gap between the calcium hydroxide and dentin in both groups as a result of polymerization shrinkage of composite resin, which has been treated with scotch bond multipurpose and single bond adhesive systems.

Interposition of calcium hydroxide between tooth and resin possesses some clinical disadvantages such as calcium hydroxide material itself can prohibit proper polymerization of the composite resin (Marshall et al, 1982). Calcium hydroxide occupies some of area that could have been used for dentinal bonding (Heitmann & Unterbrink, 1995), phosphoric acid etching weakens or dissolves the calcium hydroxide material (McComb, 1983; Hwas & Sandrik, 1984). Calcium and hydroxide under restorations may disappear with time (Barnes and Kidd, 1979), hence, it should be recommended in selective clinical situations. This vitro study can only simulate the clinical conditions as closely as possible. Identical simulation cannot be performed exactly. Questions regarding the durability of the composite dentin bond and the relationship between marginal adaptation in vitro and bacterial contamination and development of secondary caries in vivo requires further study.

Conclusion

1. In both the groups an interfacial gap was found between the calcium hydroxide and dentin.
2. Amount of interfacial gap formed between composite resin-calcium hydroxide and composite resin-dentin interfaces is not statistically significant.
3. Total bonding area may be an acceptable alternative procedure, rather than the selective bonding area.
4. The latest dentin bonding systems recently marketed forms an inter-diffusion layer with higher bond strengths, which are excellent for clinical usage.
5. Interposition of calcium hydroxide between tooth and resin possesses some clinical disadvantages. Hence should be recommended in selective clinical situations.

Bibliography:


