Original Article

Microleakage and Micrographic Evaluation of Composite Restorations with Various Bases over ZOE Layer in Pulpotomized Primary Molars

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Abstract

Objective: Zinc oxide eugenol (ZOE) under composite restorations should be covered with a suitable material in order to prevent the harmful effect of ZOE on the composite. The aim of this in vitro study was to evaluate microleakage of composite restorations in pulpotomized primary molars with different bases for covering the ZOE layer and to assess the distance between different layers.

Materials and Methods: Proximo-occlusal cavities were prepared in 78 extracted second primary molars. Carious lesions were removed and pulpotomy was carried out. Zinc oxide eugenol paste was placed in 2-mm thickness. The teeth were randomly divided in 6 groups and restored as follows: 1. Light-cured composite; 2. Resin-modified glass-ionomer and composite resin; 3. Glass-ionomer and composite resin; 4. Light-cured calcium hydroxide and composite resin; 5. Calcium hydroxide and composite resin; 6. Amalgam and composite resin. The restored specimens were thermocycled for 500 cycles (5°C/55°C) and microleakage was assessed by dye penetration technique. Three specimens from each group were processed for scanning electron microscope evaluation to determine the distance between the layers. The results were analyzed by Kruskal-Wallis and Dunn tests.

Results: Microleakage assessment revealed significant differences between the groups (P=0.04), with the amalgam group exhibiting the lowest microleakage values. In SEM micrographs no significant differences were observed in the distance between ZOE base layers (P=0.94) and base-composite layers (P=0.47); however, the amalgam group had the lowest distances.

Conclusion: The use of amalgam over zinc oxide eugenol layer in pulpotomized primary molars decreases microleakage.

Key Words: Microleakage; Composite; Zinc Oxide Eugenol

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INTRODUCTION

Stainless steel crowns (SSCs) have been the most preferred material for restoration of pulpotomized primary molars and their success has been extensively established to date [1]. Current improvements in the bond strength,

Figure 1. The illustration of microleakage grading scale used

wear resistance and the increasing demand of parents to provide esthetic restorations for children have made resin-based composites popular for the restoration of primary posterior teeth [2,3].

It has been agreed that in primary molars with pulp therapy treatments the main problem may be the cavity depth, as the floor of the pulp chamber effectively constitutes the cavity floor, resulting in long unsupported cusps [4,5]. Bonded restorations splint the cusps together and decrease cusp flexure, preventing their subsequent separation by fracture [6,7]. In addition, placement of a considerable amount of adhesive restorative material in the pulp chamber may provide additional reinforcement by altering the fulcrum of cuspal flexing [6,8].

In primary teeth adhesive restorations have many advantages over SSCs, some of those are preservation of sound tooth structure and normal contact area and increased resistance to microleakage [5,9].

In pulpotomized primary teeth a base of zinc oxide eugenol (ZOE), either plain or reinforced is placed over the amputation site to cover the pulpal floor following the coronal pulp amputation [10].

According to many investigations, a resin-based composite material should not be used over ZOE because it increases microleakage and produces poor bond strength to dentin because eugenol suppresses the polymerization of composite resin [11,12]. Therefore, it is advisable to cover ZOE with a suitable material in order to prevent the harmful effect of ZOE on composite restorations.

On the other hand, using different bases with different compositions under composite resin may influence its properties [13-15] and subsequently jeopardize the final success of the restoration. The presence of gaps in the marginal area and between various layers of restoration is one of the major causes of microleakage which is considered one of the main factors responsible for treatment failure [9].

The present study evaluated microleakage and gap formation between different bases and composite restoration in pulpotomized primary molars. The null hypothesis tested was “there is no difference in the amount of microleakage between different restorative techniques”.

MATERIALS AND METHODS

Seventy-eight extracted human primary second molars which had at least three intact surfaces, consisting buccal, lingual and one proximal surface were selected and stored in 0.5% chloramine solution for 24 hours.

The teeth were stored in distilled water during the study.

Proximo-occlusal cavities were prepared involving two surfaces only using a high-speed bur under water coolant and the cervical margins were placed in the enamel.

All the pulpotomy procedures were carried out using a conventional technique in which caries was completely removed and upon removal of the roof of the pulp chamber the pulp tissue was removed and irrigation was performed with normal saline solution. Reinforced ZOE paste (Zonalin, Kemdent, Purton, Swindon, Wiltshire, UK) was mixed according to the manufacturer’s recommendation by 5:1,

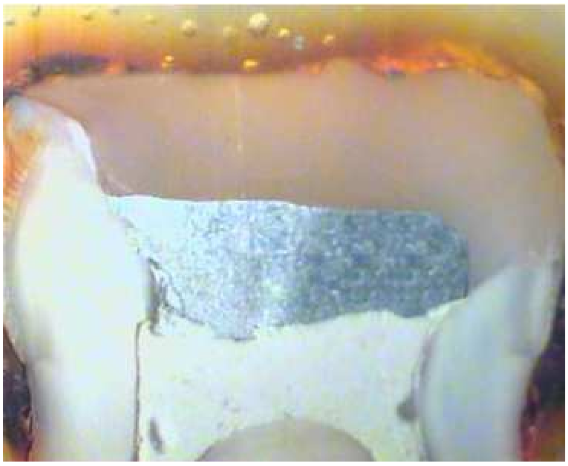

Figure 2. One of the amalgam group samples under stereomicroscope

Powder: liquid ratio with “thick putty” consistency. It was placed on the pulp chamber floor in 2-mm thickness (determined by a periodontal probe) and an approximately 2-minute interval was necessary for the setting of ZOE. The ZOE paste was not extended to the outer margin of the cavity.
The teeth were divided into 6 groups (n=13) using the simple randomization method with the flip of a coin. In order to eliminate the anatomic variations of the teeth as confounding factors only the second primary molars were used and the number of maxillary and mandibular second primary molars was the same in the groups under study (flipping of a coin has been done separately for maxillary and mandibular molars). A metal “T band” matrix was prepared for each tooth and in all cases, cavity preparations were filled with composites using incremental light cure technique.

Group 1 (ZOE group): 35% phosphoric acid (Ultraetch, Ultradent Products, South Jordan, USA) was used for acid etching for 20 seconds followed by a 30-second water rinse and the excess water was removed from the surfaces with cotton pellets. Two coats of Single Bond adhesive (3M/ESPE, St Paul, MN, USA) were applied onto the cavity walls in sequence for 15 seconds with gentle agitation and light-cured for 10 seconds with a halogen light source (Arialux, Apadanatak, Tehran, Iran).
Filtek Z-250 composite resin (3M /ESPE, St Paul, MN, USA) was placed on the ZOE layer in 2-mm-thick oblique increments and light-cured for 40 seconds.

Group 2 (resin-modified glass-ionomer group): The restorative procedures were similar to those in group 1. However, in this group, the 2-mm-thick layer of resin-modified glass-ionomer (RMGI) (GC Fuji II LC, Tokyo, Japan) which was mixed according to the manufacturer’s instructions by using one level scoop of powder to two drops of liquid covered the ZOE base by the closed sandwich technique and light-cured for 20 seconds.

Group 3 (glass-ionomer group): The adhesive procedures were the same as those in group 1.
However, the 2-mm-thick layer of self-cured glass-ionomer (GC Fuji I, Tokyo, Japan) which was mixed according to the manufacturer’s instructions by using one level scoop of powder to two drops of liquid covered the ZOE layer.

Group 4 (light-cured calcium hydroxide group): The restorative procedures were the same as described above and the 2-mm-thick layer of light-cured calcium hydroxide (Lime lite, Pulpdent, watertown, MA, USA) was placed on ZOE layer and light-cured for 20 seconds.

Group 5 (calcium hydroxide group): There were similar adhesive procedures like other groups. However, the 2-mm-thick layer of self-cured calcium hydroxide (Dycal Ivory, Dentsply, Milford, DE, USA) which was mixed according to the manufacturer’s instruction in equal volumes of base and catalyst and was homogeneous and streak free was placed over the ZOE layer.

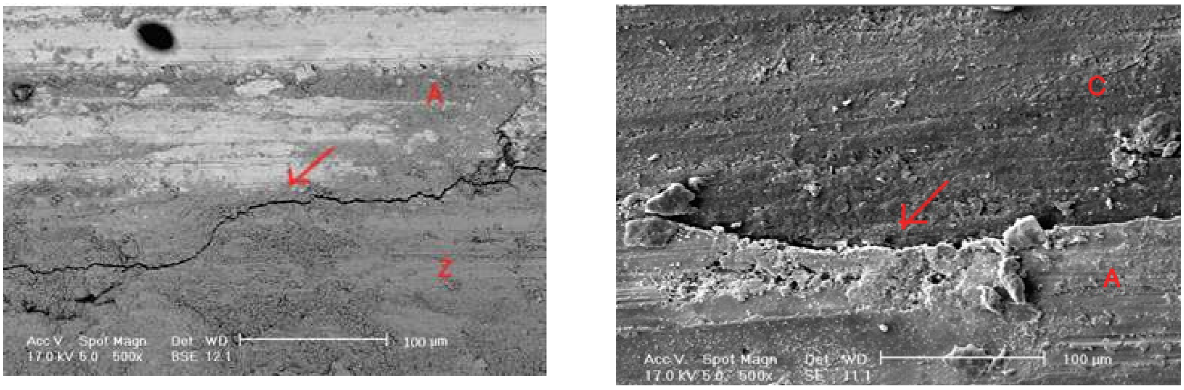

Figure 3. a) The distance (arrow) between ZOE (Z) and amalgam (A) b) The distance between amalgam (A) and composite (C) layer under SEM.

Group 6 (amalgam group):

A 2-mm-thick layer of high silver, non gamma 2, spherical amalgam (Lojic plus, SDI, Bayswater, Australia) after 8 seconds trituration was condensed in the cervical region and allowed to set for 5 minutes. Consequently, the etching, bonding and restorative procedures were done similar to those described above.

The teeth were thermocycled using 500 cycles at 5°C/55°C with a dwell time of 30 seconds. The entire tooth surface was covered with two layers of nail varnish, except for the restorations and 1mm around their margins.

The teeth were embedded in a self-curing acrylic base by using metallic molds to allow ease of handling. The specimens were immersed in 0.5% basic fuchsine solution for 24 hours, followed by washing under tap water. Then each tooth was invested in a clear self-curing acrylic resin and sectioned mesiodistally through the restoration by using a diamond blade (Isomet, Germany).

The specimens were examined under a stereomicroscope (Nikon, Tokyo, Japan) at ×20 magnification for evidence of dye penetration using the following criteria (Figure 1) 0=no leakage; 1=leakage originated at the occlusal surface only; 2=leakage originated at the cervical surface only; 3=leakage originated from the occlusal and cervical margins; 4=leakage is present at both cervical and occlusal aspects and is continuous. Three specimens from each group were randomly selected for scanning electron microscope analysis. They were gold sputter-coated with gold palladium and observed under a scanning electron microscope (XL30, Philips International Inc, Potomac, MD, USA) (Figures 3 and 4). The space between the ZOE layer base and the base-composite layers were measured quantitatively by manual microstructure distance measurement software (Nahamin Pardazan Asia Co, Iran). Data were analyzed using Kruskall-Wallis and Dunn tests.

Table 1. The percentage of leakage values for each group

	Leakage grading			
	.00	**2**	**3**	**4**
ZOE	0 (0%)	4 (40%)	4 (40%)	2 (20%)
Resin-modified glass-ionomer	2 (20%)	1 (10%)	1 (10%)	6 (60%)
Glass-ionomer	2 (20%)	6 (60%)	1 (10%)	1 (10%)
Light-cured calcium hydroxide	2 (20%)	6 (60%)	0 (0%)	2 (20%)
Calcium hydroxide	4 (40%)	5 (50%)	0 (0%)	1 (10%)
Amalgam	6 (60%)	4 (40%)	0 (0%)	0 (0%)

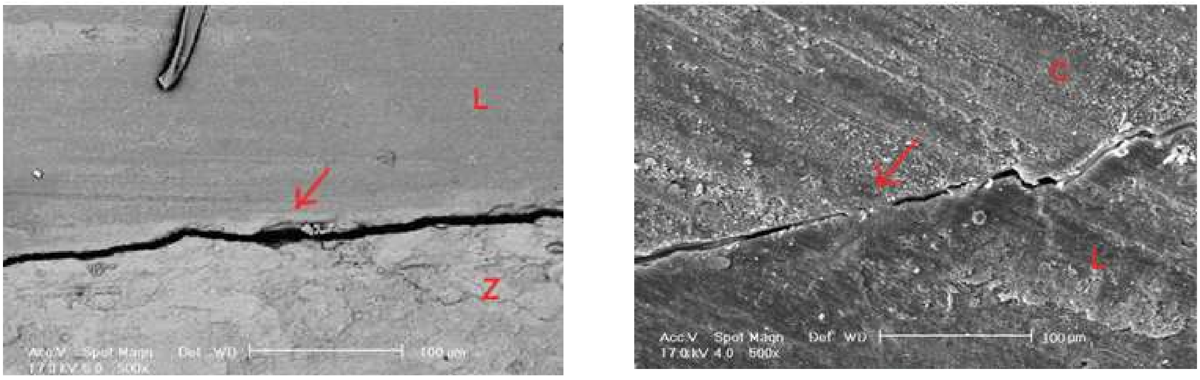

Figure 4. a) The distance (arrow) between ZOE (Z) and light-cured glass-ionomer (L) b) The distance between light-cured glass-ionomer (L) and composite (C) layer

RESULTS

Table 1 summarizes the leakage scores observed for each group of restorations. Kruskal-Wallis test showed that there was significant differences between the groups. There was less leakage in the amalgam group compared with other groups by using Dunn test (P=0.004). The mean (±SD) amount of distance between ZOE base layer (L1) and these amounts for composite base layer (L2) are shown in Table 2. The differences between the groups were not statistically significant in L1 (P=0.94) or in L2 (P=0.47); however, the amalgam and self-cured calcium hydroxide groups had the lowest space in L1 and L2 zones.

DISCUSSION

Zinc oxide eugenol is widely used in pulp therapy to obturate the root canals or to cover the pulpal floor in pulpotomized teeth. Use of ZOE for the latter reason is inevitable since replacing ZOE with calcium hydroxide was not successful [16]. Although use of resin-based composite material in direct contact with ZOE is contraindicated traditionally [17, 18, 19], in some studies evaluating the effect of ZOE on composites no adverse effect have been shown [20, 21]. In addition, it has been reported that the detrimental effects of ZOE on composite resin are only seen at a distance of less than 100 µm from the ZOE base [22]. These findings raise doubts about this interaction and effect. In the present study, ZOE under composite restoration showed the greatest microleakage; therefore, it seems necessary to cover ZOE with other materials. It has been established that various cavity bases have an influence on composite restorations as Marshall et al [23] indicated that polycarboxylate and glass-ionomer bases caused reduction in the hardness of composite restorations. In addition, the findings of Berrong et al [24] confirm the effect of glass-ionomer base on composite properties. Liners may be used to counterbalance the cusp deformation as a consequence of polymerization shrinkage of composite resin [15]. The liner must not allow polymerization shrinkage forces to create a debonding force or to form gaps between itself and the tooth or composite interface [15]. In this study, microleakag increased respectively in the following order:

Amalgam<calcium hydroxide<glass ionomer<light-cured calcium hydroxide<zincoxide eugenol≈resin-modified glass-ionomer.

Although it has been confirmed that resin-based bases have a better bond with composite materials and it is believed that light-cured calcium hydroxide has better physical properties compared with conventional calcium hydroxide [25], the findings of this study are contradictory. According to Papadakou et al [26], light-cured calcium hydroxide base under composite restoration is pulled away from the dentin floor of the cavity as a result of an apparent adhesion to composite resin during polymerization shrinkage. The justification may be relevant for resin-modified glass-ionomer too; therefore, the greater amount of microleakage in these groups might be attributed to pulling away from the ZOE layer because of better bonding to the composite. Although in determining the gap, there was no significant difference between the groups, it should be emphasized that gap is a three-dimensional phenomenon and SEM evaluation is a two-dimensional tool. It might be possible to obtain more clear results by enhancing the samples in future studies. In this study, the amalgam group exhibited the least microleakage and the lowest gap formation in L1 layer, which could be related to insolubility of amalgam and its condensability because amalgam does not create pulling forces from the cavity and its condensation force may be considered the most important factor in its marginal adaptation. These findings are contradictory with those reported by Junior et al [27], who indicated that placement of amalgam under composite restorations (amalcap technique) resulted in considerable microleakage. It should be pointed out that they used a single bottle etch-and-rinse adhesive system and cured it before insertion of the amalgam, which may have caused the leakage in that study.

In addition, they placed amalgam only at the gingival margins of the restoration and in the present study amalgam was placed on the ZOE layer. In the present study, the resin-modified glass-ionomer group revealed great amounts of microleakage due to the fragile nature of the powder/liquid glass ionomer cement. Addition of the resinous content did not improve the strength of the material sufficiently to withstand the shrinkage forces during composite polymerization [27]. Considering the lower amount of microleakage in the glass ionomer group in comparison with resin modified glass ionomer, possibly apparent adhesion of the latter to the composite resin and pulling away from the cavity floor is the reason for this difference between the two materials.

Despite various advantages attributed to calcium hydroxide, its role in microleakage of composite restorations has not been fully elucidated and it is believed that it may have a softening effect on composite resins [28]. On the other hand, in a study carried out by Lingard et al [29], Dycal had little interaction with composite resin. In the present study, self-cured calcium hydroxide had better microleakage inhibitory results compared to the light-cured one, which might be explained by findings of Papadakouet al [26], who indicated that

Table 2. L1† and L2†† values for each group

	†L1	††L2
Glass ionomer	71.09±30.22	25.11±33.72
Amalgam	6.40±1.13	3.11±2.10
Light cured calcium hydroxide	32.26±5.43	13.63±11.96
†††**ZOE**	39.13±51.64	
Calcium hydroxide	7.37±2.03	2.51±1.04
Light cured glass ionomer	52.86±39.99	6.31±3.06

†L1: Distance between ZOE and base layer (µm)
††L2: Distance between base-composite layer (µm)
††† The ZOE group only has L1 layer

Prisma VLC Dycal base was found to be pulled away from the dentin floor of the cavity as a result of an apparent adhesion to the composite resin during polymerization shrinkage.

It should be emphasized that microleakage grade 2 was evident in all the groups and as a result, none of the groups had leakage only at the occlusal surface. It is obvious that in the gingival margins the enamel is thinner and it is difficult to achieve good adhesion with dentin [30]. The situation may highlight the importance of base materials under composite resins in preventing microleakage.

Finally, the null hypothesis was refuted since some differences were observed between different techniques.

CONCLUSION

In composite restorations of primary pulpotomized molars:

1- Covering of ZOE layer with amalgam exhibited the lowest amount of dye penetration.

2-Microleakage with other bases in an ascending order was as follows:

calcium hydroxide, glass-ionomer, light-cured calcium hydroxide, ZOE and resin-modified glass-ionomer.

3-None of the examined techniques completely prevented dye penetration.

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