Original Article

An *In vitro* Evaluation of Microleakage Associated with Three Different Compomer Placement Techniques in Primary Molars

Abstract

Background: Microleakage is one of the most frequently encountered problems in posterior tooth-colored restorations. Efforts to decrease this problem with resin restorations include techniques for reducing the ratio of bonded to unbonded restoration surfaces and following strategic incremental placement techniques to reduce residual stress at tooth-restoration interface which reduces the C-factor, hence microleakage. **Aim:** The present study aimed to evaluate microleakage associated with three placement techniques for compomer restorations in primary molars. **Design and Methodology:** This *in vitro* experimental study assessed the microleakage associated with bulk-fill, horizontal-incremental, and oblique-incremental compomer placement techniques in primary molars. Ninety specimens were divided into three groups of thirty for each of the placement techniques. **Results:** Nearly 86.6% of the specimens presented with microleakage involving the entire axial wall and pulpal floor in the bulk-fill group, whereas 56.6% and 46.6% of the specimens in the horizontal-incremental and oblique-incremental groups showed microleakage up to two-third and one-third of the axial walls, respectively. A significant difference in scores was observed between groups ($P < 0.001$). **Conclusion:** Microleakage was observed with all the three techniques but was comparatively lower with the incremental placement techniques. The oblique-incremental technique offered the least microleakage.

Keywords: *Compomer, microleakage, placement techniques, primary molars*

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Introduction

Increasing demand for more esthetic restorations has led to the invention of a variety of tooth-colored restorative materials. Instead of simple lathe-cut low copper amalgam or silicate cement, the menu of available materials has expanded to include hybrid, microfilled, or optimal size particle, flowable or packable composites, glass ionomers, resin-reinforced glass ionomers, and compomers in varying viscosities. At either end of the spectrum are the traditional glass ionomers and resin composites and in between are a range of newer products with intermediate characteristics such as resin-modified glass ionomers and polyacrylic acid modified composite resins (compomers).[1,2]

The choice of materials for restoring the primary molars is very expansive and complex. The only available options several years ago were limited to silver amalgam or stainless steel crowns, whereas, today, there are numerous materials. Available since 1993, compomers were evolved from composite materials, developed as a need for new materials that could replace silver amalgam. Compomers or polyacid modified composite resins are direct light-cured restorative materials.[3] They possess some properties in common with glass ionomer cement and others with hybrid composites. Adhesion to enamel and dentin is possible due to the use of bonding systems. In addition, the restoration should act as a protective material with long-term secondary caries prevention and 3–5-year longevity in the primary dentition.[4]

Microleakage is observed to be one of the most frequently encountered problems with respect to the posterior resin restorations. Achieving a micromechanical and biomechanical bond between the tooth-restoration interface is marked as a standard procedure for an ideal restorative technique. Efforts have been made to decrease this problem associated with resin restorations. This includes various techniques for light polymerization for the reduction of the amount of resin volumetric shrinkage, reducing the C-factor, and following strategic incremental placement

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techniques which result in the reduction of the residual stress at tooth-restoration interface.[3] Various strategic restoration placement techniques have been proposed, among which the incremental placement techniques such as horizontal, split-horizontal, oblique, and modified oblique techniques are the most popular ones. The residual stresses generated by different incremental placement techniques vary, thereby decreasing the leakage at the tooth-restoration interface. The ultimate success of a material is indicated by its longevity in the oral environment. The objective of the present *in vitro* study is to compare the sealing ability of the most innovative restorative material, i.e., compomer being used in pediatric dental practice, with different placement techniques.

Methodology

Ninety sound primary molar teeth extracted for therapeutic reasons in the Department of Pediatric Dentistry, Pacific Dental College and Hospital, Udaipur, were used for testing microleakage.

Only healthy, unrestored primary molars were included in the study, whereas carious or fractured teeth and previously restored teeth were excluded from the study.

The teeth collected were divided into three groups, each group composed of thirty teeth. The extracted teeth were cleaned of soft tissue and debris and stored in saline at room temperature. The teeth were disinfected using 2% chlorhexidine gluconate solution for 24 h and stored in distilled water at room temperature. Class I cavities (4 mm length × 2 mm width × 1.5 mm deep)[5] were prepared on the occlusal surfaces of teeth using #1 round and #57 straight fissure burs in a high-speed air rotor handpiece with water coolant. No retentive features were incorporated in the cavity design. Burs used were changed after every five preparations. The cavity depth was standardized at 1.5 mm with the help of premeasured and marked #57 straight fissure burs. A graduated probe was used to further confirm the depth of the cavity.

The prepared cavity was rinsed thoroughly with air/water spray and dried. The cavities were then coated with a layer of bonding agent followed by light curing for 20 s. The cavities of each of the thirty teeth were restored with compomer using the placement technique allocated to that group as follows [Figure 1].

Bulk-fill technique

In this technique, a single layer of compomer was applied to fill the preparation up to the cavosurface margin, followed by light curing.

Horizontal-incremental technique

In this technique, the resin was layered horizontally. Each increment was cured for 40 s.

Oblique-incremental technique

In this technique, the first increment was horizontally placed over the floor. Over this, the second increment was placed obliquely, contacting the buccal surface and the axial wall along with the previously cured increment. This was followed by a third increment placed obliquely to the already placed resin. All the increments were cured again as a whole.

The restorations were polished with polishing burs. The samples were stored in distilled water for 24 h and thermocycled for 200 cycles with a dwell time of 10 s in cold and hot baths, at temperatures of 4°C ± 2°C and 50°C ± 2°C, respectively.[6] The radicular apices of all teeth were sealed using modeling wax and by application of nail varnish, except for 1–2 mm around the margins of the restorations. This was done to limit dye penetration to the cavity margins. After restoring in basic fuchsine 0.5% for 24 h, the samples were sectioned longitudinally from the middle of the cavity into two parts. Each part was observed under a stereomicroscope at ×40 magnification to evaluate microleakage.[7] The linear penetration of the dye from the external margin of the cement was scored according to the criteria given by Popoff *et al*., which is as follows [Figure 2].[8]

- Score 0: No microleakage
- Score 1: Dye penetration up to one-third of axial wall
- Score 2: Dye penetration up to two-third of axial wall
- Score 3: Dye penetration onto the entire axial wall
- Score 4: Dye penetration onto the pulpal wall.

Data were analyzed using the Statistical Package for the Social Sciences software version 19 for Windows (SPSS Inc., Chicago, IL, USA). Results are expressed as mean

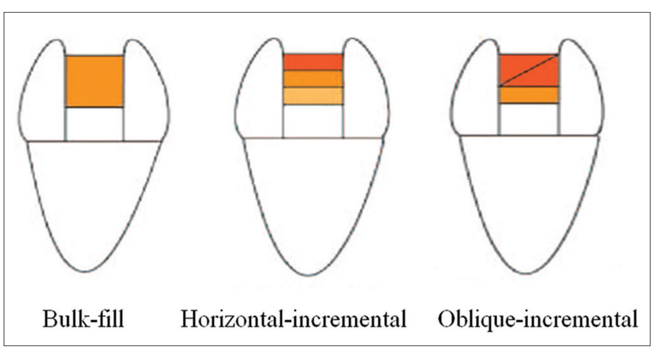

Figure 1: Compomer placement techniques used in the study

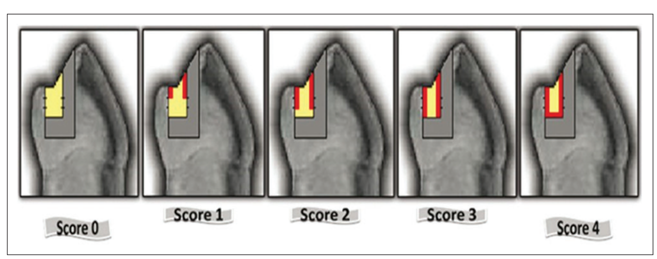

Figure 2: Scoring criteria for microleakage

with standard deviation. Chi-square test and one-way ANOVA with *post hoc* Bonferroni tests were used to assess the correlation. For all tests, $P = 0.05$ or less was considered to be of statistical significance.

Results

Table 1 presents the distribution of tooth specimens by placement technique and microleakage score. A significantly higher number, i.e., 86.6%, of specimens in the bulk-fill group presented with microleakage involving the entire axial wall and pulpal floor (score 4) ($P < 0.001$). In the horizontal-incremental group, microleakage extending up to two-third of the axial wall (score 2) was significantly more frequent, whereas, in the oblique-incremental group, microleakage extending up to one-third of the axial wall (score 1) was significantly more common. Table 2 presents the mean microleakage scores of the three groups. The oblique-incremental technique was observed to display the least microleakage. A significant difference in scores was observed between groups [Table 3].

Discussion

Advancements in the restorative materials have led to a paradigm shift in the restorative dentistry practiced years ago. Compomers are greatly popular, particularly in pediatric dentistry, because of their composite-like esthetics, ease of placement, fluoride-releasing potential, self-adhesive properties, structural strength, and good handling properties.[1] Compomers were formulated to take advantage of the properties of various materials such as resin composites, hybrid ionomers, and conventional glass ionomers.

Microleakage occurring at the tooth-restoration interface is the most frequently encountered problem with posterior resin restorations. Efforts are being made to reduce the polymerization shrinkage of resins using different techniques of restoration placement which are aimed at reducing the volumetric shrinkage and consequently, the ratio of bonded to unbonded restoration surfaces.[4] Throughout the entire polymerization process, plastic deformation or flow of resin material occurs and may partially compensate for the induced shrinkage stress. The irreversible plastic deformation takes place during the initial stage of the setting process of resin material. As the setting proceeds, contraction and flow gradually decrease, leading to an increase in stiffness. Such compensation through flow is affected by the configuration of the restoration known as the "C-Factor." Strategic incremental placement techniques have been reported to reduce residual stress at the tooth-restoration interface.[9,10] In the present study, three compomer placement techniques were tested for microleakage.

Class I cavities were chosen to be prepared onto the tooth specimens as their standardization can be done easily. The specimens were stored in distilled water since the dentin permeability is not much affected unlike saline as has been observed in various other studies.[11,12] The specimens were then evaluated for marginal adaptation under a stereomicroscope to obtain the three-dimensional view, greater depth of focus, and long working distance along with simplicity of operation. Trowbridge[13] has stated that the increase in the dwell time during thermocycling procedure, as compared to the oral cavity, could be the reason for increased microleakage observed in *in vitro* studies. Barnes *et al*.[14] compared the microleakage values of *in vitro* models and clinical situations and reported increased microleakage in laboratory experiments. This might explain the comparatively high microleakage scores in the present study. Dye penetration technique was used for the evaluation of microleakage due to its properties such as simple application, inexpensive, nontoxic, traceable at low concentration, common, and easily comparable method for evaluating of microleakage.[15-17]

The results of the present study showed that the bulk-fill technique was associated with more microleakage than the incremental techniques, which is supported by observation from other studies.[18,19] This could be attributed to increased polymerization contraction stress due to a large volume of resin and a decreased effectiveness of polymerization at the deeper portions of the restoration.[18] Ozel and Soyman[20] proposed that the incremental placement technique is the preferred restorative technique over the bulk-fill technique for posterior resin restorations as it results in better marginal adaptation. It has shown a proportional relationship between the stress relief in thin resin increments to the amount of resin porosity. The oxygen present in air voids, incorporated during the incremental technique, is observed to contribute to stress reduction.[21] Several incremental techniques have been preferred over the bulk-fill technique to restore the different forms of cavities such as horizontal increment, oblique increment, split-horizontal, and centripetal techniques. On the contrary, a few reported that neither the bulk nor the incremental placement technique was superior to each other with respect to microleakage of the resin-based restorations.[22,23]

In the current study, microleakage was seen to some extent with almost all placement techniques, but the incremental techniques displayed fewer leakage scores as compared to the bulk-fill technique. Among the incremental techniques, the oblique-incremental technique was associated with the least microleakage indicating minimum stress scores and a reduced configuration factor, with resultant improvement in marginal seal.

Resin restorative materials are versatile and their usage in combination with other materials has continued to grow since their introduction into dentistry. Microleakage remains the major factor determining the long-term success of resin-based restorative materials.[24] Within the limitations

Table 1: Distribution of tooth specimens by placement technique and microleakage score

Group	*n* (%) of specimens showing varying microleakage scores					*P*
	Score 0	Score 1	Score 2	Score 3	Score 4	
Bulk-fill (*n*=30)	0	0	0	4 (13.3)	26 (86.6)	0.001*
Horizontal-incremental (*n*=30)	0	1 (3.3)	17 (56.6)	11 (36.6)	1 (3.3)	0.001*
Oblique-incremental (*n*=30)	0	14 (46.6)	12 (40)	2 (6.6)	2 (6.6)	0.001*

Chi-square test. *Significant

Table 2: Mean microleakage scores of test specimens

Group	Number of specimens (*n*)	Microleakage (mean±SD)
Bulk-fill	30	3.87±0.350
Horizontal-incremental	30	2.47±0.570
Oblique-incremental	30	1.57±0.630

One-way ANOVA with *post hoc* Bonferroni test. SD: Standard deviation

Table 3: Comparison of mean microleakage scores of test specimens

Group	Mean difference	*P*
Horizontal-incremental versus oblique-incremental	0.90	<0.001*
Horizontal-incremental versus bulk-fill	−1.4	<0.001*
Oblique incremental versus bulk-fill	−2.3	<0.001*

*Highly significant. One-way ANOVA with *post hoc* Bonferroni test

of this study, it can be inferred that placing compomer in increments reduces microleakage as compared to the bulk-fill technique. Oblique-incremental technique provided an adequate marginal adaptation in Class I cavities of primary posterior teeth.

Conclusion

From the results of the present study, the following conclusions may be drawn.

- None of the insertion techniques tested could completely eliminate microleakage
- Significantly lower microleakage was observed with the incremental placement techniques when compared to the bulk-fill technique
- A significant difference in microleakage was observed between the incremental techniques
- The least microleakage was observed with the oblique-incremental technique.

The findings of the present study support the use of incremental placement techniques, in particular, the oblique-incremental technique for compomer restorations in primary teeth.

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Conflicts of interest

There are no conflicts of interest.

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